Vol. 52 No. 3 January 1959

Quarterly

of the

National Fire Protection Association

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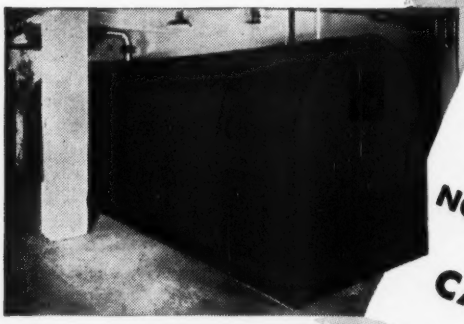

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Vol. 52 No. 3 January 1959

Quarterly

The Standard Technical Journal of Fire Protection for More Than Fifty Years

The NFPA is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with a total membership of 17,000. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include *Fire News*, *Advance Reports* to the Annual Meeting, a *Year Book*, and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control. Six volumes of the National Fire Codes are available on an annual subscription basis, one volume free and others at reduced membership rates. For full details on available material ask for the free "List of NFPA Publications."

NFPA annual dues are $15.00 for Associate Membership of which $6.00 is for subscription to this Journal. National and regional societies or associations may apply for an organization membership for which annual dues are $100; such a membership entitles four individuals to receive the periodical membership publications.

Technical committees of the Association develop means to safeguard life and property through the publication of standards covering all phases of fire prevention and protection. Your membership in the Association affords an opportunity to keep abreast of these developments and, by being a member, you help support this humanitarian activity. Popular educational literature on fire safety is constantly being produced by the NFPA for distribution through its members to the general public.

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International

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Quarterly

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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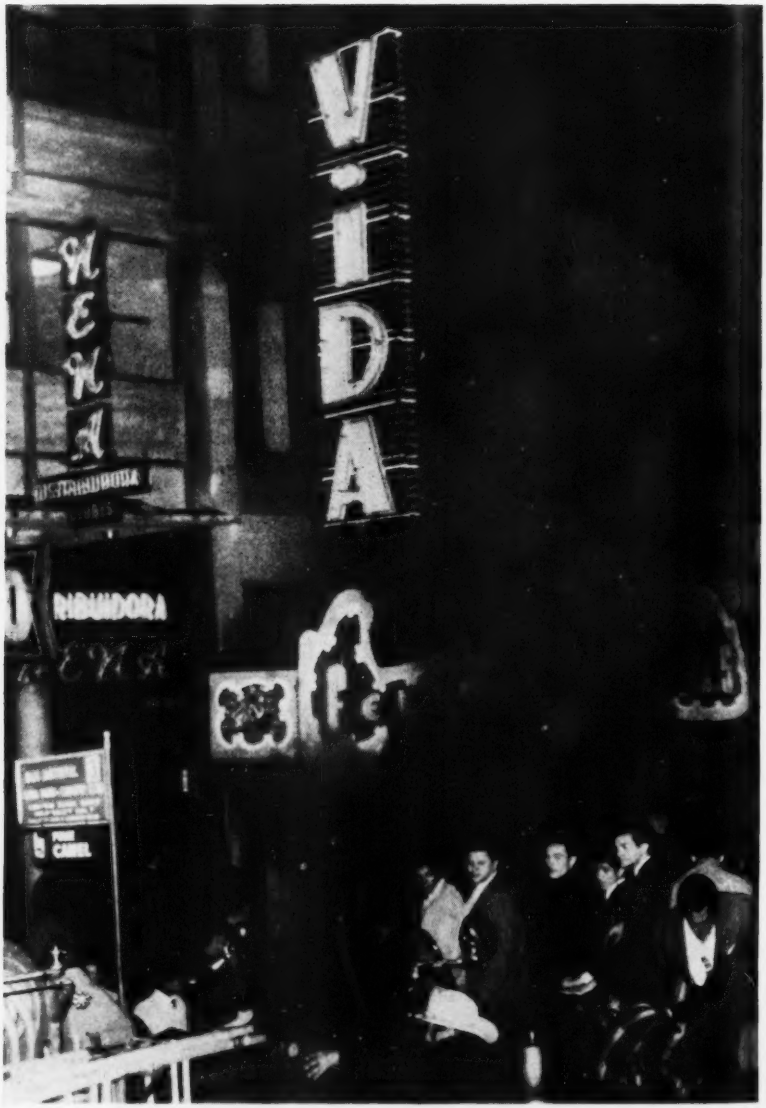


The Vida Department Store at Bogota, Colombia was the scene of a fire December 16, 1958, that took the lives of 83 shoppers and clerks. Occupying the first story of a 23 ft. wide by 197 ft. deep 3-story building, the store violated a basic life safety rule by providing only one way out—the front entrance. The fire originated in a crèche made of flimsy combustible material midway between the front and rear of the narrow store. Shoppers and clerks between the fire and the street left by the front entrance but those in the rear of the store, on being confronted by a wall of fire between them and the front, turned toward the rear in search of another way out. There was none. For further details, see January 1959 NFPA "Fire News."

Editorials

California Conflagrations?

CALIFORNIA is growing tremendously. At the present rate it will before long be the first U. S. State in population. One of the major factors of this growth is the climate — comfortable outdoor weather, little rainfall and minimum need for artificial heat. There are some regional exceptions to the salubrious climate, but it is sufficiently general to maintain the almost explosive population growth.

The increased population has been largely housed in vast new subdivisions, probably constructed in accordance with local building codes, but to our untutored eyes built with practically no attention to fire safety. The worst hazard is the wood roof. Houses are generally only a very few feet apart, extending acre after acre. Wood shingles are not limited to dwellings, but are found on large supermarkets and other buildings constructed in these new subdivisions. Light frame construction and plywood add to the hazard.

No fires of truly conflagration proportions have yet happened although during December two major brush fires went out of control and destroyed over 50 homes. More severe results might yet come after long periods of very low humidity and high winds. A brush or building fire could throw sparks over tinder-dry wood shingles, and we could have a repetition of the experience of other wood shingle roof conflagrations.

The fire departments of California are of the best calibre. Well trained and highly efficient, they can be expected to give a good account of themselves under any conditions where any fire department can cope with a fire situation. However, there are situations, with hundreds of simultaneous wood shingle roof fires merging into a general conflagration, where no fire department of any practical size can be expected to provide effective protection. Furthermore, many of the fire departments in California have not kept pace with population growth, and many of the new wood shingle roofed subdivisions have inadequate protection by any reasonable standard.

Why has this situation developed? Is it largely a building code situation where fire departments have relatively little influence on building code requirements and the building officials lack fire experience? Have fire departments themselves failed to recognize and take action on this hazard? Have the wood shingle salesmen been more active there than in

other parts of the country where wood shingles are little used for new roofing? What can be done about it, save making requirements to stop further use of wood shingle roofing? Must we wait for another wood shingle roof conflagration?

Fire Research

THE article by Professor Emmons in this issue of the QUARTERLY describes the fire research program of the U. S. National Research Council of the National Academy of Sciences. This is an ambitious program of fundamental research, largely guided by combustion experts without extensive experience in the field of fire protection. What will result from this research activity is problematical; we hope it will provide most valuable information in time.

Challenging and interesting as this program is, we can't help feeling that a great many important research projects in the fire field are stalled because of lack of funds, projects which should provide fire protection design criteria for buildings, for elimination of sources of ignition, for control of the spread of fire within and between buildings, for better extinguishing methods. These projects in the field of practical research, all too often languish except where related to the sale of some product.

As far as city conflagrations are concerned, we already have the answers to their prevention — perhaps not the best answers, but at least sufficient knowledge to build cities that are far less susceptible to sweeping fire than are present urban areas. For example, why do we permit wood shingle roofs at all? Just substituting fire safe roofing, and separating combustible buildings, would eliminate the conflagration hazard from large areas, and also the susceptibility to mass ignition from radiant heat. We also know the importance of keeping outdoor litter cleaned up and other simple measures. But the danger of conflagration, or of fire storms, is too remote to bring any effective action.

There is a great gap between the research of the physicists and combustion experts and the actual practice — a gap that must be closed by more practical fire research and more widespread public education in the principles of fire safety. The general public still wallows in abysmal ignorance of fire protection. Consider, for example, the recent fire in a George Washington University fraternity house in Washington, D. C. In this case, the interior was decorated to simulate a coal mine, the walls were lined with tar paper, and shavings were placed on the floor to a depth of several inches. Nature took its course, and in spite of a manual fire alarm system that worked, and fire escapes, two students were burned to death.

Legal Compulsion or Moral Suasion

THE tragic nonsense of exempting a building from compliance with fire safety laws enacted after the building is built was never more painfully demonstrated than by the recent Chicago school holocaust. (See page 155.)

The fact that this disaster happened to occur in Chicago is neither comfort nor cause for complacency elsewhere.

There you had essentially a 48-year-old structure, little if any different from hundreds of other old school buildings around the country. There is no reason to doubt that it complied with the laws prevailing when it was built, but it did not comply with fire law provisions enacted by Chicago ten years ago and it certainly violated many well-recognized principles of life safety from fire. More is known today about life safety from fire than was understood a half-century ago. How long are we going to try to live in the past?

Any competent fire chief, fire marshal or other fire protection expert should have no trouble recognizing a multi-story school building with unprotected stairways as a fire trap, particularly a building of combustible interior construction without automatic sprinklers. Is it right that no pressure is brought to bear to alleviate such dire threats to life merely because such a building is of pre-ordinance vintage and hence outside the law?

Is it possible that this fire in Chicago and others like it in the past and in the future must be accepted as practical necessities simply because they are "legal?" We do not believe so. Moral suasion can often do what the law cannot. We believe that few if any school authorities would dare to ignore written notification by a competent fire official that a particular building to which the public was invited was indeed a fire trap. Their liability and culpability in the face of such information would compel them to act.

If we are to continue to ignore the moral violations and be concerned only about violations of the law, which in most cases provides only a limited measure of fire safety, then it seems clear that thousands of innocent persons are doomed to fiery deaths until at long last all known fire traps burn and the law finally catches up with reality.

It Can Happen Here

FOR many years we have been predicting a department store fire with major loss of life. It is only by the Grace of God, with the assistance of automatic sprinklers, that no such fire has yet happened in the United States or Canada. But many stores have no automatic sprinklers, and sometimes even when there are sprinklers, the water is shut off. The ingenuity of the store designer is always concentrated on getting customers *into* the store. How they would get *out* in an emergency is left very largely to the law enforcement agencies, and exits are often of indifferent value.

Fires with major loss of life occurring in other parts of the world seem to exert little influence on store managements in North America. The Christchurch, New Zealand fire with the loss of 41 lives went almost unnoticed here.* Now we have the fire in Bogota, Colombia (see frontispiece) which duplicates conditions found in stores in many parts of North America. A long, narrow store, with no exit except at the front, no automatic sprinklers, a combustible fiberboard ceiling, and a rapidly spreading fire that cut off access to the one exit for a large number of people in the store. Do we have to have a store fire in the United States or Canada that burns a hundred or a thousand people to death before we will apply these lessons?

Erratum

Apologies are extended to author David Warren and to our readers for an error made in the article on Geodesic Aluminum Domes in the October 1958 QUARTERLY, page 107. The statement thereon that "Of course, one pound of steel would carry more load than one pound of aluminum" is incorrect and was unintentionally printed. A pound of steel will carry less than half as much load as a pound of aluminum.

*The NFPA reports this fire in its Occupancy Fire Record on Department Stores (FR 54-7) and in the January 1948 QUARTERLY (frontispiece).

Fire Protection Developments in 1958

By Percy Bugbee, General Manager

National Fire Protection Association

Preliminary estimates of the U. S. fire loss experience in 1958 indicate that there will be a slight increase in the dollar loss. However, it is our considered opinion that the actual amount of property destroyed by fire is probably not as great as it was some years ago. The inflationary trend of recent years makes dollar estimates of fire loss somewhat misleading.

NFPA publishes each fall estimates of the fire loss by occupancy and by cause and a brief comment on the trends indicated in this study over the past ten years may be of interest. The number of U. S. building fires has increased 33% in the ten-year period. The estimate was 570,000 building fires in 1948 and 843,900 building fires in 1957. Fires in dwellings increased in the same period 49%. There were 270,000 estimated dwelling fires in 1948 and 530,000 in 1957. No such pronounced increase is indicated in either mercantile or manufacturing occupancies as in the dwelling occupancy. The principal cause of fires over all of the ten-year period was careless smoking and handling of matches. In 1948 there were 115,000 fires attributed to this cause and in 1957, 169,000.

Notable Fires of the Year

Unquestionably the fire that caused the greatest interest and concern in 1958 was Our Lady of the Angels School fire in Chicago reported in this QUARTERLY. This tragedy occurred on December 1 and cost the lives of 90 children and three adults. To my mind, a tragic factor here was that there are really no new lessons to be learned from this fire. It is the old story of open stairways, poor housekeeping practices, delayed discovery and delayed alarm, and lack of automatic fire protection in the building. About the only comforting note following a disaster of this proportion is the solid fact that as a result of the fire schools all over this country are getting a very thorough inspection for fire hazards and many defects in construction and protection are being corrected. Perhaps the over-all saving in life as a result of this wholesale improvement in school fire protection will be substantial.

Two other fires that attracted major attention in 1958 both occurred in New York City. The first of these was the garment factory fire that occurred on March 19 which caused the deaths of 24 employees.* The other was the fire in the Museum of Modern Art that occurred on April 15.** In all of these three major fires of the year, the principles well established by the Building Exits Code, which is the national standard of life safety in buildings prepared by the NFPA Committee on Safety to Life, were violated. The Building Exits Code spells out in detail the proper construction, protection and exit provisions for all sorts of buildings. This Code has gone through many editions over many years and is the product of some of the very best minds in fire protection. Its principles can be applied in any existing building where there is a hazard to life.

Fire Departments

In general, it can be said that our 20,000 odd fire departments, both paid and volunteer, throughout the country, are continuing to improve in matters of fire fighting techniques, training, and fire prevention activity. The modern and progressive fire department is a

*See April 1958 FIRE NEWS.

**See July 1958 QUARTERLY, page 67.

highly complicated and skilled organization. The efficient fire departments not only prevent and suppress fires, but they are now providing rescue and emergency service in a large variety of accidents and emergencies in addition to their fire fighting duties. As observed in recent years in our year-end summary, there are many of our fire departments that are obviously seriously undermanned and the department that is not at good strength cannot do effectively all of the jobs that the modern fire department is called upon to do.

The new NFPA Committee on Fire Department Organization is making an intensive study of the problems of modern fire department administration and operation which we believe will throw a good deal of light on the proper way to carry out fire department functions.

It is gratifying to be able to report that the principle of dwelling inspections by fire departments is gaining ground and each year more departments participate in a simple inspection of all of the dwellings under their jurisdiction. We would again observe that this plan not only brings about a marked reduction in loss of life in dwelling fires and in the incidence of dwelling fires, but that it is done at no extra expense to the taxpayer and with very great public support value to the fire department. How well this program works can be illustrated by the experience in Richmond, Calif. which has been carrying on an intensive house to house inspection program for a number of years. In 1951 Richmond had 426 dwelling fires and these fires dropped progressively until 1957 when there were reported only 52 dwelling fires. The Chief gives full credit to the home inspection program.

Firemen's training continues to expand. We estimate that in the state and provincial programs alone some 119,000 firemen received training. This is in addition to the many excellent training programs conducted by individual municipalities.

A special contribution to the fire service during the year was the publication by the NFPA of Dr. William D. Claudy's book entitled "Respiratory Hazards of the Fire Service."

Rural Fire Problems

With the great growth and expansion of the country, more and more industrial establishments and mercantile areas are locating in outlying sections. The importance of a sound rural and farm fire protection program is increasingly evident every year. More of the large loss fires occur in rural areas, substantial fire loss is experienced in farm properties, and considerable loss of life occurs in farm dwellings.

It is increasingly evident that we need to devote more time and attention to the organization of fire protection and prevention in the farm and rural areas of the country and we are hopeful that more work will be done in this area.

Urgency at Airports

Another aspect of fire protection which concerns us is the fact that with the development of jet transports it becomes imperative to provide more adequate fire protection for U. S. airports. NFPA has had available for some years specific recommendations for aircraft rescue and fire fighting services for civil airports. With the increases in passenger travel, the larger capacity of the new aircraft and the heavier density of air traffic, this matter is of unparalleled urgency.

National Fire Defense

Recently the U. S. federal Office of Civil and Defense Mobilization has appointed a National Fire Defense Advisory Committee to prepare a national fire protection plan for the country in the event of enemy attack. The findings of this group have not yet been made public, but in general it can be said that the group believes that a proper state-wide program for fire defense should be created in each of the 49 states.

Standards

New fire protection standards of great general interest were presented at the 1958 NFPA annual meeting in Chicago last May. Included among those that were adopted in revised form are the Specifications for Motor Fire Apparatus, Organization of Volunteer Fire Departments, the Flammable Liquids Code, the Standard for Liquefied Petroleum Gases, Portable Fire Extinguishers, the Building Exits Code, Signaling Systems, and Sprinkler Systems.

Public Education

In the field of general fire prevention education, it is satisfying to report continued progress. The well-known national observances, such as Fire Prevention Week, and the spring clean-up campaign, continue to grow and there is evidence that almost every community, large or small, participates in these educational activities. In the NFPA contest conducted in the U. S. and Canada for year-round effectiveness in fire prevention activity, Phoenix, Ariz. and Ottawa, Ontario, emerged as the Grand Award winners for 1957.

It is pleasing to report that Sparky, the firehouse Dalmatian dog that has become the symbol of fire prevention to thousands upon thousands of children throughout the United States and Canada, continues to catch the imagination of the younger generation. Many Sparky Fire Departments have been organized in communities all over the continent and are doing a brilliant job of fire prevention education.

Throughout 1958 the Boy Scouts of America undertook a program for safety (the Safety Good Turn project) which included fire safety. NFPA, the International Association of Fire Chiefs, and other national fire organizations gave strong support to this program.

An interesting special contribution to fire prevention education in 1958 was the production by the New York State Education Department of a very comprehensive and attractive manual on fire prevention education, providing information from the kindergarten through Grade 12.

Wood Shingle Roofs

We continue to be concerned with the large numbers of dwelling tracts, particularly in southern California and in areas of Texas, where all of the roof coverings are wood shingles. Older students of fire prevention will recall vividly the large number of wood shingle roof conflagrations that took place throughout the country in the earlier part of the century. Any real recurrence of the popularity of the wood shingle for roof coverings will inevitably bring a recurrence of the conflagration hazard.

Amateur Rocketry

A new and special hazard of particular concern to the safety of life and limb occurred during 1958 when a large number of youngsters, mostly of high school age, undertook amateur experiments with rockets. Our records indicate a very considerable number of serious injuries and some deaths from this activity. We have pointed out that the NFPA model fireworks law covered this hazard quite adequately and many state fire marshals and other public officials have been using the fireworks law as a means of controlling this special hazard.

NFPA Services at Peak Demand

A review of 1958 indicates very clearly that there is a marked increase over-all in general public awareness of the fire hazard and the need for doing something about it. This is perhaps the most significant favorable trend of all. NFPA has never had greater demand for its services or publications than it has had in 1958. In any one year the progress made in fire protection and prevention is hard to measure, but if we measure the progress made over a decade or more the evidence is very clear that much is being done that was not done earlier and that more and more of our public are being trained in fire safety.

The Chicago School Fire

By Chester I. Babcock, Manager and Rexford Wilson, Engineer

NFPA Fire Record Department

Chicago Tribune

Shortly before classes were to be dismissed on December 1, 1958, fire broke out at the foot of a stairway in the Our Lady of the Angels School, Chicago, Illinois. Ninety pupils and three nuns at this Roman Catholic grade school lost their lives when smoke, heat and fire cut off their normal means of escape through open stairways and corridors. Seventy-seven were seriously injured.

Grateful appreciation is given to Chief F. W. Kempf of the Chicago Fire Insurance Patrol, to Chicago Fire Commissioner R. J. Quinn and his staff, to Mr. Elmer Reske of the Cook County Inspection Bureau and to others in the Chicago area for their cooperation and assistance during this investigation.

The School Building

The fire was confined to one wing of the U-shaped 2-story brick, wood-joisted building (see diagram 1). The north wing, where the fire occurred, had been built in 1910 and originally housed a church on the first floor and parochial school classrooms on the second. After a new church was built on adjoining property in 1949, the church-school building was converted to a classroom building, and in 1953 it was connected to another old 2-story brick, wood-joisted building (located at the corner of W. Iowa and N. Avers Sts.) by a 2-story brick, wood-joisted annex. The first and second stories of the resulting U-shaped building were

Chicago Sun-Times

This photo was taken from the grade level landing in the rear stairwell of the north wing. The fire started at the basement level landing where the four men are standing. The window in the left background broke early in fire. Two doorways from basement level are not visible. At the first floor level the Class B fire door that kept fire and smoke out of the first story is seen standing ajar.

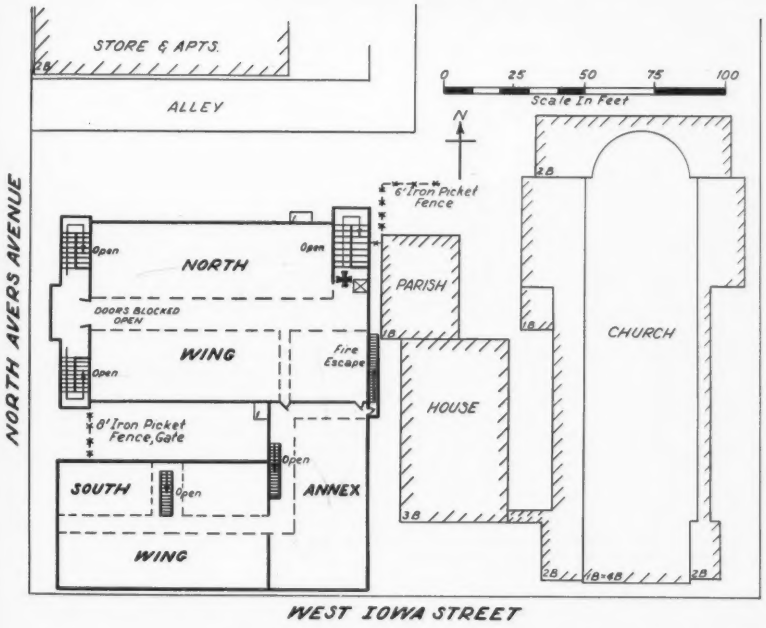


Diagram 1. Plot plan of school and adjacent property. Second story details of school building shown. Fire started at basement level of stairway marked by cross.

occupied by classrooms. A chapel was in the basement of the north wing, and there were three classrooms in the basement of the south wing.

Open interior stairways and lack of standard protection for doorways in the masonry division wall between the north wing and the annex made the entire building essentially one fire area. For further information on construction see "Construction Details" on page 167.

An exact count of the number of people in the school at the time of the fire is not known. Conservative estimates place the total at between 1200 and 1300. It is known that there were 569 pupils and teachers in the north wing, of whom 329 were in the six second-story classrooms.

Origin of Fire

At 2:00 P.M. most of the pupils were in their classrooms with their teachers receiving the final hour's instruction before the scheduled 3:00 P.M. dismissal.

Sometime prior to 2:25 P.M. fire broke out in combustible material at the bottom of the rear stairway of the north wing. A pupil "sneaking a smoke" in this stairway is one possible cause. Following the fire a partially burned bundle of newspapers, a book of wallpaper samples, a package of old exam books, and the remains of a roll of asphalt-saturated felt were found among other combustible material in the debris.

Discovery

At 2:25 P.M. the teacher of Room 206 (see diagram 2) started two of her pupils on the normal routine of taking the class wastebaskets down to the boiler room incinerator. They returned at 2:30 P.M. to say that they smelled smoke. The teacher told her class to remain seated as she hurried to Room

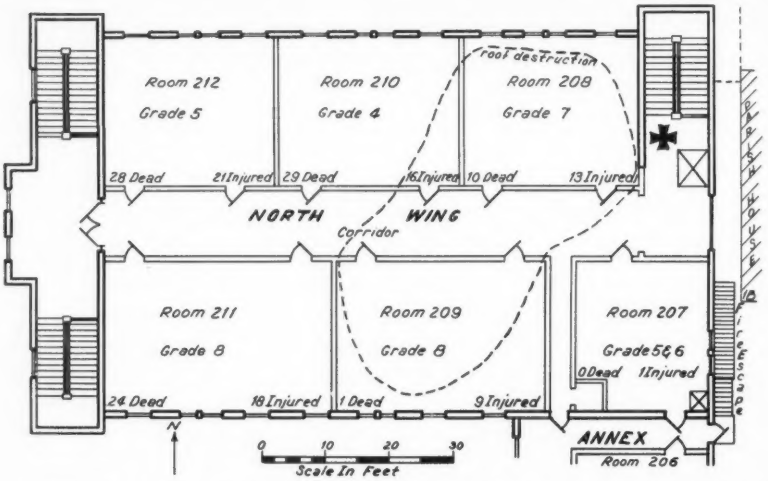


Diagram 2. Second story of north wing. Fire started at basement level of stairway marked by cross. After this diagram was drawn one of the 16 injured in Room 210 died. Casualties, Room 210 should read 30 dead; 15 injured.

207 to ask what she should do. After being advised of the smoke the teacher of Room 207 ran down the corridor to the principal's office in the middle of the south wing to alert her. The principal was not there as she was substituting for a sick teacher on the first floor.

The Room 207 teacher then returned to her classroom. She and the teacher of Room 206 decided to take their classes out of the building. The pupils in Room 207 went out through the cloakroom and down the fire escape stairs, while those in Room 206 went down the annex stairs and outdoors. Smoke was already at head level in the second story corridor.

Both classes were taken to the church after which the teacher of Room 206 ran back to the school, went to the first floor of the south wing and operated the fire alarm signal. The time was now about 2:42 P.M.

Meanwhile, the school janitor was returning along W. Iowa St. to the school building from other school property several blocks away. At approximately 2:25 P.M. he entered the alley between the parish house and the school and saw smoke in the rear, near the stairwell. He says he ran into the boiler room, then ran to the parish house and

United Press

The 40 pupils and their teacher who were in Room 207 escaped down this fire escape.

yelled to the housekeeper to call the fire department. He then ran back into the boiler room and started through the building. According to the fire department, the housekeeper's call was its first notification of the fire. This call was received at 2:42 P.M., suggesting that she may have delayed placing the call. The standard response to a telephoned alarm — one engine, one ladder truck, one rescue squad and a battalion chief — was dispatched. A unit of the Chicago Fire Patrol also responded on this alarm.

At about the same time, the fire department alarm office received the first of fifteen other telephoned alarms, none of which came from anyone in the school building. A passing motorist on North Avers Avenue saw smoke coming from around the outside door to the rear stairwell of the north wing. He stopped his car, and since there was no fire alarm box in sight, rushed into a small neighborhood grocery store just north of and adjacent to the school and asked for a telephone. On being told that there was no *public* telephone he said, "I wanted to report a fire in the school!" and rushed out to try to find a telephone somewhere else. The store proprietress followed him out and went toward the school. She saw no commotion or unusual activity inside but on approaching the doorway to the rear stairway she saw a tongue of flame coming from over the door. She then ran back to her store and telephoned the fire department over her *private* telephone. This call was made at approximately 2:43 P.M. She was told, "Help is already on the way." On immediately returning to the school she found children at open second story windows calling for help.

Chicago Tribune

View of second story corridor of north wing, looking from front stairway landing. Fire originated in rear stairway beyond the arch in center background of photo. Door to Room 212 is at left foreground.

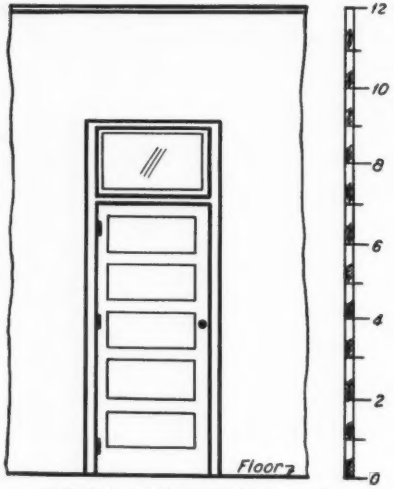
Hot smoke and fire gases that came up the open rear stairway and mushroomed through the second story corridor of the north wing had been noticed by occupants of classrooms off the corridor before the building alarm rang.

The building fire alarm gave the first notification to all other occupants of classrooms except those in Room 206 (annex) and Room 207, as noted.

Spread of Fire

During the five or ten minutes that the fire burned before discovery it is surmised that it developed rapidly. Burning was greatly intensified when the window in the stairwell at basement level was broken by the heat, permitting a good supply of fresh air to enter the fire area. Hot fire gases and smoke billowed up the chimney-like stairwell and mushroomed through the second story corridor at ceiling level. From all available indications there was no actual burning in the second story at the time second story occupants first noticed smoke. However, the occupants of several of the classrooms in the second story of the north wing reported that after doors had been opened and then quickly closed to keep out smoke a "whoosh" was heard. This noise is thought to have accompanied the ignition of fire gases and combustible interior finish in the corridor. As heat began breaking large glass transoms over the doors, hot fire gases and flames entered the classrooms. Fire also entered the shallow roof space through a ventilation grill in the corridor ceiling.

This was the apparent situation in the second story of the north wing when the first piece of fire apparatus arrived. Since the major efforts of firemen had to be directed toward rescue during the early stages, the fire in the second story grew steadily worse and eventually burned off about one third of the roof before being controlled.



TYPICAL SECOND FLOOR CLASSROOM DOOR

Scale In Feet

Escape

On hearing the building fire alarm, occupants of the entire first floor left the building by the five available stairways to the street, apparently without confusion and unaware of the fire.

Evacuation of the second floor of the annex and south wing was hampered by smoke which came through an open door in the division wall at the second story level. This door was closed early in the fire, possibly by a fireman who had entered the building to assist in rescue, or by the janitor. While many of the occupants of the second story of the south wing and annex reached the street without difficulty, there were instances of panic and of rescue by civilians. When some of the pupils of a second story classroom in the south wing refused to leave, their teacher ordered them to crawl to the stairway. When they balked at the stairway, she rolled and pushed them down. Several pupils in the second story of the south wing were taken down fire department ladders.

Stories of the actions of the occupants of classrooms in the second story of the north wing are not complete, but it is possible to reconstruct fairly reliable accounts of what went on in the six rooms.

Room 207

In Room 207, at the top of the rear stairwell (see diagram 2) the 24 fifth grade and 16 sixth grade pupils had just settled down after returning from a music lesson in another part of the building. The door to the corridor was closed.

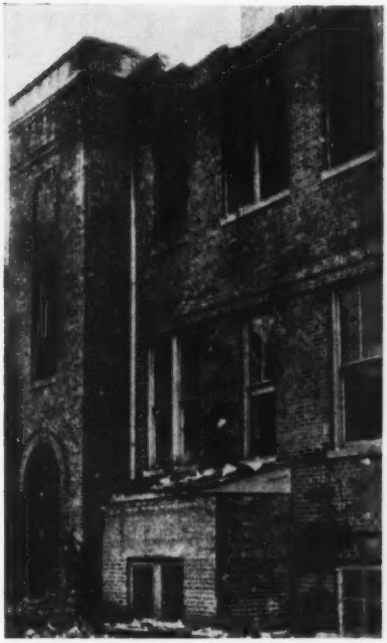
Chicago Tribune

The cloakroom between Rooms 206 and 207 shows the way coats were hung in the main corridor of the north wing at the start of the fire. Note the height of the fire extinguisher to the right of the 7-ft.-high door to the fire escape.

Shortly after 2:30 P.M. the teacher from Room 206 came in and talked briefly with the teacher of this room, telling her of the smoke odor detected by two of her pupils. (For additional details see pages 157 and 158.) A few moments later she ordered her class to go out through the rear classroom door to the fire escape. No building fire alarm was given at this time. Escape by this route was temporarily delayed, however, when the pupils could not open the rear classroom door. One report says the door was locked, another that it was stuck. Following instructions a boy jumped from a window to the fire escape. If it was the plan of the teacher to evacuate her class by this route, it was not necessary to do so for the janitor arrived at this moment and forced open the stuck or locked door. Thereafter all occupants of Room 207 filed down the fire escape and to the church. No dead; one injured.*

Room 208

The 46 seventh grade pupils in Room 208 first learned of the fire when smoke poured in under the door from the corridor. Ordered into fire drill formation by their teacher, the pupils attempted to leave via the corridor but were forced



United Press

Many occupants escaped from Room 208 in the second story by jumping to the roof over a basement stairway shown just beneath first story windows. The stairway where fire started is at left.

*The injuries mentioned herein (total: 77) are those that required extended hospitalization.

Chicago Tribune

The quick-thinking teacher of Room 209, who took firm control of her class, had much to do with the fact that only one child died in this room. Note the vacant spaces on the walls that had been filled with highly combustible pressed paperboard blackboards.

back into the room by smoke and flames. Panic gripped them as they ran for the windows. Some jumped to the raised roof of an outdoor basement stairway; about twenty-five managed to escape down two short extension ladders raised by the assistant janitor. But ten did not get out before flames flashed through the room. Nine pupils and one teacher dead; 13 injured.

Room 209

During a mathematics lesson in Room 209 one of the 62 pupils raised his hand and reported smelling smoke. On opening the door and finding the corridor filled with smoke, the teacher slammed it shut and then went into action as follows. Boys were ordered to pile books at cracks around doors while the girls were ordered to the windows. Boys were next told to pile desks in front of doors. Despite these efforts smoke and heat continued to push into the room. Looking across the courtyard to class rooms in the south wing the teacher noticed that no one was aware of the fire. She started her class chanting, "Fire! Fire! The school's on fire!" to attract attention.

About this time the occupants of Room 209 heard a "whoosh" from the corridor. Through the transom flames could be seen roaring along the corridor at ceiling level. The manually operated building fire alarm started to sound. The children remained calm and some of them received permission to drop from a window to the canopy over an outside stairway from the first floor to the ground. Others, however, remained at the windows until taken down fire department ladders or until pulled by a civilian into an adjacent window of the annex. Seeing no other pupils in the smoke-filled room the teacher went to the ladder, but as she started down saw a girl still in the room. This pupil died before being rescued. One pupil dead; nine injured.

Room 210

Details of the actions of those in this room are incomplete. Geography had just begun for the 56 fourth grade pupils when smoke was seen coming in from under the doors. Many were burned by flames before they jumped. Several bodies were found in a pile beneath windows. 29 pupils and one teacher dead; 15 injured.

Room 211

Details of the evacuation of the 64 eighth graders in Room 211 are not complete. Panic gripped the children as smoke poured in a slightly opened transom. A priest yelled from the ground for them to use the front stairs, but because of the smoke and heat in the corridor, this was impossible. Some

Chicago Sun-Times

Many of the fourth graders in Room 210 died beneath these double windows. Height of windows above floor 37½ inches.

Wide World

Room 211, remote from the rear stairway had a high casualty list. Note heavy fire damage. Room 212, across the hall, suffered the highest number of casualties but very little fire damage.

jumped; some were taken down fire department ladders. 24 pupils dead; 18 injured.

Room 212

Fifty-five fifth grade pupils were studying geography in Room 212. Because the room seemed warm the teacher asked to have the windows opened and then asked a boy to open the door to the corridor. Smoke rolled into the room. The door was shut and the teacher told the pupils to stay in their seats and pray but as the room filled with choking hot smoke many pupils rushed to the windows and jumped. Others stayed at windows and were rescued by firemen while a few who stayed at their seats were asphyxiated. An electric clock on the wall of this room stopped at 2:47 P. M. 27 pupils and teacher dead; 21 injured.

Fire Department Response

Because of the repeated telephone calls, Chicago Fire Alarm Headquarters supplemented the telephoned alarm response by sounding the number of the nearest street box, located one block east and one block south of the school property. Sounding of this box at 2:44 P.M. brought two ladder companies, four engine companies and two chief officers to supplement the ladder company, engine company, rescue squad, fire insurance patrol and battalion chief that had been dispatched on the telephoned alarm at 2:42 P.M. On finding children jumping from second story windows, the engine company responding on the telephoned alarm radioed for a box alarm immediately after arrival. This call was received simultaneously with the striking of the box by the

alarm headquarters crew. At 2:47 P.M., after the battalion chief responding on the still alarm arrived, a second alarm was ordered. Special calls for a total of ten fire department ambulances were made at 2:50 P.M., 2:52 P.M., and 2:55 P.M. At 2:57 P.M. the battalion chief ordered a fifth alarm. A special call at 3:08 P.M. was made for two additional ladder companies and two additional rescue squads, bringing the total fire fighting and rescue equipment at the scene to 22 engine companies, seven ladder companies, five rescue squads, one fire insurance patrol, three high pressure units, two water towers, ten fire department ambulances, seven chiefs, and two commissioners. The police department responded with over 70 squadrols (patrolling stretcher-equipped panel trucks).

Rescue

Before the first fire apparatus arrived many children had already jumped from windows. The assistant school janitor with the help of a priest had obtained two extension ladders from a nearby garage and had placed them against the wall beneath Room 208. They were too short to reach the window but about twenty-five pupils were able to reach them from window sills.

Several outsiders rushed into the building in an attempt to save those trapped in the second story of the south wing and annex. One man checked the entire first story and found everyone out. Another is reported to have been seen leaving the building with four children under his arms and a third is said to have guided a small group of youngsters

Chicago Sun-Times

Room 212, located farthest from and least damaged by the fire, sustained the greatest number of casualties. Note the congestion of desks. The heavy smoke conditions are indicated by the dark color of the walls under the blackboards and by smoke-free spots on the desks.

down one of the stairways. These rescue efforts and those of the teachers that have been previously described are thought to have been all that took place prior to arrival of firemen.

Rescue operations by fire department personnel consisted primarily of catching pupils and in throwing all available ladders up to windows as fast as manpower would permit. Since Engine 85, first in, had the recommended five man complement, it was possible for the officer to divide his men. While part of the crew laid in a 2½-inch hose line, the remainder used the engine's 24-foot ladder and roof ladder to start rescue operations on the north side of the north wing. Ladder Company 35, first in, on seeing children at windows of the south wing, started rescue operations from that part of the building. Rescue Squad 6, first in, helped ladder the building and broke out life nets. These are the first of innumerable heroic and often tragic rescue efforts by members of the Chicago Fire Department and the Chicago Fire Insurance Patrol. Estimates indicate that these men were responsible for saving 160 lives.

While some of those who jumped did not require immediate medical attention and were able to run to their homes, most of them were hurried to one or another of four surrounding hospitals in fire department ambulances and police squadrols. Activation of hospital disaster plans greatly facilitated efficient handling of the victims.

Fire Extinguishment

The remaining men of Engine 85, running a hose line to the rear stairwell, started extinguishment operations. The second in engine ran two hose lines up

Wide World

Many children were taken down fire department ladders before they were asphyxiated or burned to death. When this picture was taken those still in the building were dead. A new type of fire department apparatus used experimentally by the Chicago Fire Department and known as the Pitman "giraffe" is shown in use.

the front stairs and used fog nozzles in an attempt to make the corridor usable for rescue. This attempt had to be abandoned, however, when the men were forced down the stairway.

As engine companies arrived additional hose lines were laid and the fire was soon brought under control.

Construction Details

One Fire Area

The building was one fire area due to the open stairways and the fact that the masonry division wall between the north wing and annex had substandard doorway protection. There were two wooden doors in this division wall at the second story level. The fact that one of these doors was closed when the fire occurred and the other was closed shortly after the fire was discovered prevented the fire from entering the second story of the annex from the second story of the north wing. The fire eventually burned through these doors but by then fire department hose streams were in operation to keep the flames from entering the annex. A similar door in the division wall at the first story level was chained open but since the fire did not enter the first story this deplorable condition was not a factor in the outcome.

Chicago Tribune

Narrow hallway between Rooms 207 and 209 looking toward annex. Door at end of hallway was closed early in fire. There was negligible fire damage beyond this door. Open stair from second to first floors of annex in background.

Heights and Areas

The basement level was 4½ feet below grade and the first floor 6 feet above grade. The second story floor was 15 feet above the first. Ceiling heights were 9 feet in the basement, 14 feet in the first story and 12 feet in the second.

Gross floor areas* of the basement, first and second floors of the entire building were approximately 12,000 square feet each, — total gross floor area of the building 36,000 square feet. In the north wing each gross floor area was 6,400 square feet, — total gross floor area 19,200 square feet. The basement of the north wing was occupied by the chapel, boiler room and girls' toilet facilities; the first story contained four classrooms and toilets; and the second story six classrooms (see diagram 2).

Exits

Five interior and one exterior stairways were distributed as shown in diagram 1. From the 84-foot-long main corridor in the second story of the north wing three stairways led to lower floors and the street, one at the rear of the corridor and two at the front.

The rear stairway (where the fire started) in the north wing was enclosed on all four sides at basement and first story levels by brick walls with a finish of wood lath and plaster on wood furring. At the second story level the stairway was enclosed with this same material but only on three sides. Interior wall openings were as follows: at the basement level wooden doors (metal sheet on one side) opened into the rear stairway from the boiler room and from

*Gross floor area is the total floor area within the perimeter of the outside walls.

the girls' toilet room. A Class B fire door cut off the stairway from the first floor corridor. The top of the stairway opened on a second story landing, which in turn opened into the second story main corridor as shown in Diagram 2. Exterior wall openings in this stairwell were a 31 inch by 45 inch wood-framed, plain glass window at basement level, a pair of wood panel doors at the grade level landing, a 46 inch by 96 inch window at first floor level, and a 42 inch by 84 inch window at the landing between the first and second floors.

The stairs in the rear stairway were constructed of wood except for asphalt and rubber tile surface finish and a metal nosing on the treads. There were two flights of stairs and an intermediate landing between each floor, each stair having a 7-inch riser and 10½-inch tread. The under surfaces of the flights and landings were finished with metal lath and plaster. There were two units of exit width* provided by this stairway (52 inches wide).

The two front stairways in the north wing were essentially of the same construction as the rear stairway and opened on a common landing at the second floor level. Each of these two front stairways provided 2½ units of exit width (each 56 inches wide). The common landing was separated from the second story corridor by two wood and plain glass doors which were open at the time of the fire.

In the 2-story annex a one unit, open stairway of metal construction extended from the second story to an open corridor of the first story. Thirteen feet from the bottom of these stairs and directly ahead was a flight of 11 steps, at the foot of which was a landing with a door to the sidewalk.

An outside Class C fire escape stair (with swinging lower section) representing ½ unit of exit width* (36 inches wide) was attached to the rear wall of the 2-story annex and accessible from the second story corridor of the annex.

The only stairway from the second story of the south wing was an open wooden flight of stairs of one unit of exit width discharging into the open first floor hallway. Six and one half feet ahead, an 11-step stairway led to a landing with a door to the sidewalk.

Interior Finish

Walls and ceilings in the building were generally wood-lath and plaster. Ceilings of all classrooms were finished with combustible cellulose fiber acoustical tile cemented directly to the plaster. It was also cemented to the ceilings of the first story corridors of the north wing and annex. There is difference of opinion as to whether this combustible tile was on the ceiling of the second floor corridor of the north wing. The Chicago Fire Department and members of the combustible acoustical tile industry say it was not, while the church official in charge of the school states that it was. Burned pieces of the tile were among the debris in the corridor on the day following the fire.

Throughout this building there was wood interior trim in the form of doors, door frames, transom frames, mop and coat hook boards. Furniture was constructed principally of wood, and in the second story of the north wing there were pressed paperboard blackboards in the rooms and a large amount of children's clothing (it was below freezing outside) hanging from hooks along both sides of the main corridor.

Plastered walls had been given several coats of paint which at one location in the north wing measured 1/48 of an inch in thickness. It is not felt that this thin

*A unit of exit width as defined in paragraph 3011 of the NFPA Building Exits Code is 22 inches and is considered to be the space necessary for the free passage of one file of persons. Fractions of a unit are not counted except that 12 or more inches are counted as ½ unit.

*Each 18 inches of width of Class C fire escape stairs is counted as ¼ unit of exit width because steepness and other substandard factors slow travel.

coating contributed materially to the spread of fire.

Fire Protection

There was neither automatic sprinkler nor automatic fire detection equipment in the building.

Private fire protection consisted of soda-acid fire extinguishers, standpipe and hose systems and a manually operated building fire alarm signal system. The tops of the 2½-gallon soda-acid extinguishers were eight feet above the corridor floor (maximum recommended height 5 feet). Two standpipes in the north wing were one half inch less in diameter than the 2-inch minimum recommended for buildings of this height, and access to valves and hose racks was difficult because they were six feet above the floor.

The building was equipped with a manually operated fire alarm system designed to sound an alarm in all parts of the building. The system was not connected to the fire department. Ordinary electric light switches to operate the alarm system were mounted six feet above the floor. They were not marked in any way to indicate they were fire alarm controls.

The nearest public fire alarm box was one block east and one block south from the school and was not visible from any point on or adjacent to the school property. Hydrants were well distributed and fed by large mains.

Structural Damage

Although the fire inflicted severe damage throughout the second story of the north wing and burned off about one-third of the roof, it did not break out of the stairwell at the first story and basement levels. It is thought that the roof damage was the result of fire initially entering the shallow roof space

Chicago Sun-Times

A view of Room 208, taken from a wall opening chopped by a rescue squad. The roof over the room had collapsed. Note heavily burned ceiling tile in the debris.

through the ventilation grill in the north wing corridor ceiling outside Room 208. Eventually the fire burned up through the plaster ceiling over the rear stairway.

The two wood panel doors opening into the base of the stairwell, one from the boiler room and the other from the toilet room, were both burned off their hinges. Although it might appear surprising that there was no fire damage in either the boiler room or toilet room, the lack of fire damage was probably because of a strong inrush of air into the stairwell from these rooms as soon as the doors failed.

The Class B fire door at the first floor stairwell landing was intact following the fire except for cracking of the 100-square-inch wired glass window in it and slight warping of the exposed metal surface of the door. This door prevented all fire and smoke from entering the first story of the north wing.

The wood stairs in the stairwell were heavily burned and the top flight had collapsed. Most of the plaster on wood lath finish of the stairwell, including that on the ceiling, had been destroyed, but it is interesting to note that the wood roof over the stairwell was not burned through.

It Need Not Have Happened

Again it must be written that the lessons learned from this fire repeat lessons learned in years gone by. Again it must be said that conformity to the provisions of the Building Exits Code* would have prevented this disaster. Again it must be wondered how much longer it will be before the lessons so tragically brought home repeatedly by school disasters are applied to all schools.

The loss of life in this fire was primarily due to *inadequate exit facilities*** as discussed in the following section on exits. This is a basic principle of life safety from fire. Five other weaknesses in the fire safety of the building also made major contributions to this holocaust.

Exits

Basically, the adequacy of exits is determined by proper enclosure, by provision of at least two ways out remote from each other, and by sufficient exit capacity so that all occupants can leave the building promptly. In none of these respects were the exit facilities of Our Lady of the Angels School adequate.

Preordinance Building

In 1949 the city of Chicago adopted a Municipal Code which incorporated all the major features necessary for life safety from fire in buildings, including enclosure of stairways in schools. However, important provisions of this code, including enclosure of exits, did not apply to the north and south wings of Our Lady of the Angels School and to other schools in existence when this code was adopted. In other words the substandard exits in all but the annex (built in 1953) were of preordinance vintage, hence the non-retroactive law did not apply. Why the annex stairs were not enclosed to comply with the law is not known.

Exit Enclosure

The Building Exits Code requires that all stairways in school buildings be enclosed so that in case of fire the occupants can escape without danger from fire, smoke, fumes and resulting panic. The stairways in Our Lady of the Angels School were open except the two in the

*The nationally recognized NFPA Building Exits code is the standard reference on adequate exit facilities from Buildings.

**After reviewing this report Fire Commissioner R. J. Quinn stated that he disagreed with the conclusion reached by the NFPA investigators, that the principal cause of loss of life was inadequate exit facilities. Commissioner Quinn, feeling that the exits in this building were adequate, believes that the principal cause of loss of life was delayed alarm to the fire department.

Chicago Tribune

Looking down one of the two front stairways from the second story landing of the north wing. Rear stairway where fire started was similar in construction.

front of the north wing. These stairs were enclosed at the second story level by substandard doors which were blocked open at the time of the fire. (See photo on Page 173.) It would have been fairly simple and inexpensive to enclose all stairways properly. If this had been done the 93 lives lost in this fire would have been spared.

Exit Capacity

The 9½ units of exit width from the second story of this building were sufficient to permit 570 people to reach the ground in 1 minute and 20 seconds, according to exit capacity requirements set forth in the Building Exits Code and elsewhere. It is conservatively estimated that there were 610 people on the second floor of the building when the fire occurred. A closer examination of the distribution of exit capacity shows a striking contrast between the exit provisions for the north wing as opposed to those for the rest of the building.

In the north wing, the seven exit units were more than adequate *in capacity* to handle the 329 people on the second floor. In the annex and south wing, however, there were only 2½ exit units available to accommodate the 281 people believed to be on the second floors of these two sections. Two-and-one-half units of exit width are adequate to evacuate only 150 people in 1 minute and 20 seconds. The inability of the 2½ exit units to handle the 281 people in the prescribed time was demonstrated by the fact that the average time for the evacuation of the second floor in eight exit drills in 1958 was slightly more than three minutes. Had additional exit capacity been provided to accommodate the excessively high population density in the annex and south wing

through erection of stair towers, slide escapes or fire escape stairs accessible from individual rooms the occupants of the second stories of these two sections could have reached the ground without having to pass through smoke-filled corridors and stairways.

As demonstrated by the loss of life in the north wing, however, adequate exit capacity is not the only consideration, or even the most important consideration, when evaluating the adequacy of exits. Of primary importance is the enclosure of exits to assure that the ways out of the building will be free of smoke and heat when needed.

Two Ways Out

Since there is always a possibility that fire or smoke may prevent the use of one exit, at least one alternate exit must be provided, remote from the first. Because of the fact that the three stairways from the second floor corridor of the north wing of Our Lady of the Angels School were all connected through the common corridor, the pupils in the second story classrooms had in reality no safe way out. The simple expediency of enclosing the three stairwells at the second story landings would have corrected this situation. The requirement for two exits could also have been met by erecting stair towers, slide escapes or fire escape stairs accessible from individual rooms.

Sprinklers and Exits

There is no question that if a complete, properly installed and adequately maintained automatic sprinkler system had been in Our Lady of the Angels School the fire at the base of the stairwell would have been quickly extinguished before smoke of any consequence had penetrated the upper story. It is, however, questionable practice to rely on fire extinguishment to the neglect of exits because of the possibility of both human and mechanical failure. Automatic sprinklers and stairway enclosures complement each other and both should have been installed in this school.

In existing buildings that lack enclosed exits and where it may be impractical or too expensive to enclose them, the Building Exits Code suggests the following substitute. The school building can be occupied safely if both 1) it is equipped with a standard automatic sprinkler system, and 2) if there is a standard exit of sufficient capacity from each room so that the occupants can escape without passing through any corridor which could be blocked by smoke, heat or fire. This condition may be met in various ways, such as providing doors leading directly outside from first floor rooms and by direct access to fire escape balconies from every room on upper floors.

Smoke Vents in Stairways

In the absence of an automatic smoke vent at the top of the stairwell where the fire started, all products of combustion from the fire in the stairwell were forced into the second story corridor. The presence of a vent would have reduced considerably the amount of smoke and hot fire gases that entered the corridor. A smoke vent, however, is not a substitute for proper stairway enclosures. It should be used in conjunction with such enclosures.

Interior Finish

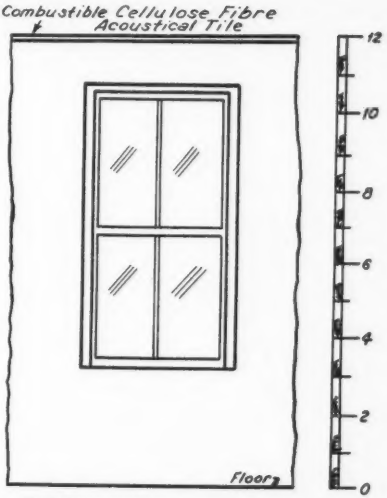
It is generally recognized that in the interest of life safety in schools interior finish should be noncombustible (Class A, flame spread 0–20)* or at least slow burning (Class B, flame spread 20–75). The Building Exits Code, however, allows up to 10 per cent of the aggregate area of walls and ceilings of corridors and exitways to have a combustible Class C rating (flame spread 75–200). No interior finish with a higher flame spread rating is permitted. The wood trim in the second story corridor of the north wing with a Class C flame spread rating, represented about 17.5 per cent of the aggregate corridor area.

*Interior finish materials are classified by the tunnel test method (NFPA No. 255) in which asbestos-cement board has a rating of 0 on the flame spread scale and red oak lumber a rating of 100.

As previously indicated, there is difference of opinion as to whether or not the ceiling of the second story corridor was finished with combustible cellulose fiber acoustical tile. A finish of this material would increase by 23 per cent the aggregate corridor area with Class C (tile with flame retardant coating on exposed surface) or Class D (untreated tile). Because of the open stairways and the large amount of other combustible material present, the results of this fire can be satisfactorily explained without the presence of a combustible ceiling finish.

The ceilings of all classrooms in the second story of the north wing were finished with combustible cellulose fiber acoustical tile.

It is important to recognize the fact that even if this building had been of fire-resistive construction the results of



Chicago Tribune

Second story landing at front of north wing. Open door at left was one of two at opening to corridor. There were no doors at other end of corridor.

this fire would have been similar because of the combustible material available at the bottom of the stairway, the absence of doors at the top of the stairway, and the combustible interior finish.

Detection

As again clearly demonstrated by this fire, the fact that a building is populated is no guarantee that a fire will be discovered promptly.

A complete automatic sprinkler system would have detected and extinguished the fire in its incipiency. An automatic fire detection system installed throughout the school would probably have discovered the fire before the second story corridor became impassable. Automatic protection in itself, however, is not a substitute for properly enclosed stairways. It is desirable supplementary protection.

In Case of Fire

It is a cardinal rule of life safety that at the first indication of fire (which is usually smoke) all occupants of the building and the fire department should be alerted simultaneously. From the time the teacher of Room 206 was first told that there was smoke in the building until she operated the building fire alarm, it is estimated that 13 minutes elapsed. Her actions during this vital period have already been described under "Discovery." They clearly indicate that adequate steps had not been taken at this school to assure proper emergency action by the teachers in case of fire, nor had a sufficient number of building fire alarm controls been provided.

Had the building fire alarm been rung when the fire was first discovered it is probable that the second story corridor of the north wing would still have been passable.

The alarm system at this school was not connected to the fire department alarm headquarters, and no one in the school telephoned the fire department.

Fire Alarms

Interior Alarms

The substandard condition of the manual fire alarm system in the school should be noted. The alarm sending switches were not readily accessible to most of the occupants of the building, they were only two in number and were not distinguishable from ordinary electric light switches. Had readily identifiable fire alarm stations been distributed throughout the building it is likely that at least one of the people who first noticed smoke would have operated the building alarm system many minutes sooner.

Exterior Alarms

According to the present Municipal Code of Chicago and the recognized standard for the installation of public fire alarm boxes*, all schools should have a fire alarm box at or near the entrance. Had a box been so located at Our Lady of the Angels School it is probable that the first alarm would have been transmitted to the fire department by the passerby at least one or two minutes earlier. Furthermore, the box alarm would have resulted in response of a box alarm assignment on the first notification of the fire. This would have brought three additional engine companies and one additional ladder company to the scene three or four critical minutes earlier.

The NFPA Building Exits Code recommends that any building fire alarm system be arranged so that when operated to alert occupants of the building it will simultaneously transmit an alarm to the fire department. Automatic sprinkler systems and automatic detection systems should be arranged to operate building and fire department alarm systems simultaneously.

Housekeeping

Following the fire the remains of a large amount of combustible material

*NFPA No. 73, Standard for Installation, Maintenance and Use of Municipal Fire Alarm Systems.

(bundled newspapers, exam papers, etc.) was found among the debris at the base of the stairwell where the fire started. The school authorities stated that combustible material was not supposed to be accumulated in this area. At the base of and under each of the two front stairwells, however, there was a wooden storage closet in which wooden chairs, screen panels and other combustible materials were stored; and a former pupil of the school stated that in 1957 newspapers from a paper drive were stored at the foot of the rear stairway. Good housekeeping is thus again emphasized as a cardinal fire safety principle.

Summary

The ninety-three deaths in this fire are an indictment of those in authority who have failed to recognize their life safety obligations in housing children in structures which are "fire traps." Schools that lack adequate exit facilities and approved types of automatic sprinkler or detection equipment, and which possess excessive amounts of highly combustible interior finish, substandard fire alerting means and poor housekeeping conditions must be rated as "fire traps." School and fire authorities must take affirmative actions to rid their communities of such blights.

By Contrast —

The Kenilworth School Fire

At 1:10 P.M., December 16, 1958 fire broke out in the 46-year-old brick, wood-joisted section of the 2-story elementary school at Kenilworth, Illinois. It originated in combustible material stored in a wooden closet at the basement level of a stairway. Here the similarity between this fire and that at the Our Lady of the Angels School ends.

On discovering the fire a school custodian's first inclination was to fight it but he immediately remembered the importance of giving the alarm. Running up the stairs he yelled to a teacher to call the fire department while he himself tripped the building fire alarm system.

As the 650 children marched out of the building, the janitor returned to the basement to find that the fire was being extinguished by the two sprinklers in the closet. None dead; none injured.

An interesting sidelight of the fire is the fact that as a result of the Chicago disaster the Kenilworth School Board had asked the Winnetka Fire Marshal to review again the school's fire protection. Kenilworth relies on Winnetka for its public fire protection. Acting on one of the fire marshal's recommendations the school superintendent revised his exit drill procedure to include drills with one exit blocked. By coincidence the exit chosen to be blocked in the latest of these exit drills was the stairway in which the fire occurred.

Although smoke made this stairway impassable, closed stairway doors prevented smoke from entering corridors. Finding this stairway impassable, the children reversed their exit travel and walked through smoke-free corridors to smoke-free stairways while the sprinklers completed their extinguishment.

Planning for School Fire Safety

The following article is reprinted from a 1946 NFPA pamphlet on school fires, with editorial revisions to bring references up to date. This pamphlet sets forth the principles of fire prevention and fire protection for schools. It is the responsibility of school boards to understand these principles and to obtain the services of a professional fire protection engineer to be sure that these principles are properly applied.

Fire safety does not necessarily involve any considerable expense, but only intelligent thought and action *before* the fire. Information on safe practices is freely available in the publications of the National Fire Protection Association and from other sources.

The Committee on Safety to Life of the National Fire Protection Association has since 1913 been studying the school fire situation and has incorporated in the Building Exits Code, the official standard of the National Fire Protection Association on this subject, a chapter outlining the fundamental requirements necessary for reasonable safety to life in school buildings. These recommendations were developed by a representative committee of experts, including fire protection authorities, architects, engineers, school administrators and others, which has studied school fire experience and finds that substantially all of the major loss of life in school fires in the past has been clearly due to violation of one or more of the cardinal principles of school fire safety as outlined in the Building Exits Code.

Building Construction

Fire resistive construction is desirable for all school buildings, but the use of building materials that will not burn does not protect against the burning of combustible contents. The one-story school, so arranged as to afford direct access to the outside from any part of the building, is the safest design, and when this form of design is used there is little restriction as to the type of construction. In any case the design should be such as to minimize the spread of fire from its point of origin. No highly combustible wallboard or other quick burning interior finish should be used. Most important is the protection of stair shafts so that fire in a basement or lower floor will not spread to upper stories. The spread of smoke and fire gases may be just as disastrous as actual fire. Information on good practices in building construction will be found in NFPA Standards No. 80, 82, 82A, 90A, and 211.

Exits

There should always be at least two safe means of escape from any area, so that in case a fire starts in or near one exit, it will be possible to escape by an alternate route. Exits should be remote from each other; two stairways leading to a common street floor area may both be blocked by a single fire. Outside fire escapes at best are of limited value and should be recognized only to correct exit deficiencies in old buildings. Many other essential features of exit requirements for schools are covered in the Building Exits Code.

Segregation of Hazards

Boiler rooms, waste paper rooms, laboratories, manual training and domestic science rooms, carpenter and paint shops and similar rooms having more than the ordinary fire hazard should be so arranged as to minimize the danger of fires spreading to other areas. In large schools it may be feasible to have such hazardous occupancies in separate buildings. In any case it is fully practicable to safeguard and protect the hazardous areas with fire resistive walls and ceilings, fire doors at all openings and auto-

matic sprinkler protection so as to give reasonable assurance that any fire starting in the room will not spread.

Alarm Systems

A manually operated fire alarm system is essential so that in case of fire all occupants will be informed immediately. The usual arrangement is an electrically operated alarm system, with conveniently arranged sending stations, and gongs or other sounding devices, used for fire alarm purposes only, loud enough to be heard in all parts of the building. In small schools a hand operated gong may be sufficient. Automatic fire detection systems are valuable in providing prompt notification of any incipient fire. It is also of utmost importance to have reliable facilities for calling the nearest municipal fire department. A standard fire alarm box should be mounted on or near the main entrance of the school building. Manual and automatic building fire alarm systems should be arranged to operate this box and thereby notify the fire department. For installation details on alarm systems see NFPA Standards No. 71, 72, 73.

Exit Drills

The Building Exits Code specifies "fire exit drills," rather than "fire drills," to emphasize the fact that the objective is getting the children safely out of the building, and that fire-fighting activities should never be allowed to jeopardize life-safety. In drills the emphasis should be placed upon orderly controlled exit rather than speed alone. Drill procedure should be sufficiently flexible so that it can meet any emergency. For example, should a fire occur in or near a main exit, the children should be marched to some other exit. All these details are covered in principle in the Building Exits Code, but it must be left to the individual school authority to work out their application to individual school buildings, with due consideration to the arrangement of the individual building, character of the school population, and other factors.

Extinguishing Equipment

Automatic sprinkler protection is recommended for all school buildings of combustible construction and also to protect hazardous areas in buildings of fire resistive construction. Fire extinguishers should in any case be provided, selecting types suitable for the type of fire likely to occur at any location. There should always be a good water supply available for the fire department with hydrants located conveniently to all buildings. For the installation of some types of extinguishing equipment see NFPA Standards No. 10, 13, and 14.

Heating, Ventilating and Air Conditioning

It is generally understood that heating equipment must be safely installed, but the danger of ventilating and air conditioning equipment is frequently overlooked. A system designed to circulate air throughout the building may, unless safeguarded, be the means of the rapid spread of fire and smoke. A small smoky fire in one room might thus have fatal results throughout the building. A system designed in accordance with the NFPA Standard No. 90A avoids such dangers.

Electricity

The National Electrical Code as developed by the NFPA National Electrical Code Committee and generally accepted throughout the country should be observed in all electrical installations.

Housekeeping and Maintenance

Good housekeeping and proper maintenance of equipment of all kinds are most important factors in the fire safety of any school. Good housekeeping includes elimination of all unnecessary combustible materials from every part of the building, particularly from attics, basements, and inaccessible storage spaces. All sorts of mechanical and electrical equipment must be properly maintained to minimize fire hazards. Extinguishers must be recharged periodically and automatic sprinklers and alarm sys-

tems checked at regular intervals. All this should be the specific responsibility of the school management. It is also desirable wherever possible to have an independent outside check through a fire prevention inspection at periodic intervals such as made by insurance organizations and fire departments.

Typical NFPA Fire Protection Publications Applicable To Schools

These publications are available from the Publications Department, National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass. Complete list available on request.

No.	Fire Protection Standards	Price
10	Portable Fire Extinguishers	$ .60
13	Sprinkler Systems	1.25
13A	Sprinkler Maintenance	.50
14	Standpipe and Hose Systems	.25
30	Flammable Liquids Code	.60
31	Oil Burning Equipment	.60
52	LP Gas Piping, Appliances in Buildings	.50
54, 54A	Gas Piping, Appliances in Buildings	.50
70	National Electrical Code	1.00
71	Central Station Signaling Systems	.50
72	Proprietary Signaling Systems	.50
73	Municipal Alarm Systems	.50
80	Protection of Openings	.50
82, 82A	Incinerators, Rubbish Handling	.50
90A	Air Conditioning Systems	.50
101	Building Exits Code	1.50
198	Fire Hose, Care of	.50
211	Chimneys and Flues	.50
232	Protection of Records	1.00
601	The Watchman	.35
701	Flameproofed Textiles	.35

Miscellaneous Other Publications

Automatic Sprinklers for Schools	per hundred	$3.00
Doin' Somethin' About School Fires		.25
Fatal School Fire, Cheektowaga, N. Y.		.25
Fibreboards, Combustible		.25
Handbook of Fire Protection		10.50
Laboratories — Occupancy Fire Record		.50
Public Schools — Occupancy Fire Record		.50
School Inspection Short Check List	per hundred	1.50
Sprinklers Beyond the Water Mains		.25

Teaching Aids

The National Fire Protection Association has many publications designed to assist those teaching fire prevention in schools. For information write the Publications Department.

Aircraft Fire Detection Should Come of Age

By Harvey L. Hansberry

Assistant to the President for Flight Safety, Fenwal, Incorporated
Chairman, Executive Division, NFPA Committee on Aviation

The purpose of this article is to review the existing philosophy dealing with the operation of aircraft powerplant fire detectors and overheat detectors, to suggest proper uses for the two devices, and to suggest methods for increasing the reliability of detecting systems.

History

Aircraft powerplant fire detection is approximately eighteen years old — and it should be attaining some degree of maturity. The Civil Aeronautics Administration began its studies of powerplant fire protection in 1939 and the earliest useful results involving detection began to take shape in 1940. Powerplant fire detectors used in the early tests were generally modifications of detectors used in other fields and, although they were somewhat less than ideal, they did point the way to future developments.

Presented at the Flight Safety Foundation's International Air Safety Seminar, Atlantic City, New Jersey, November 10–13, 1958.

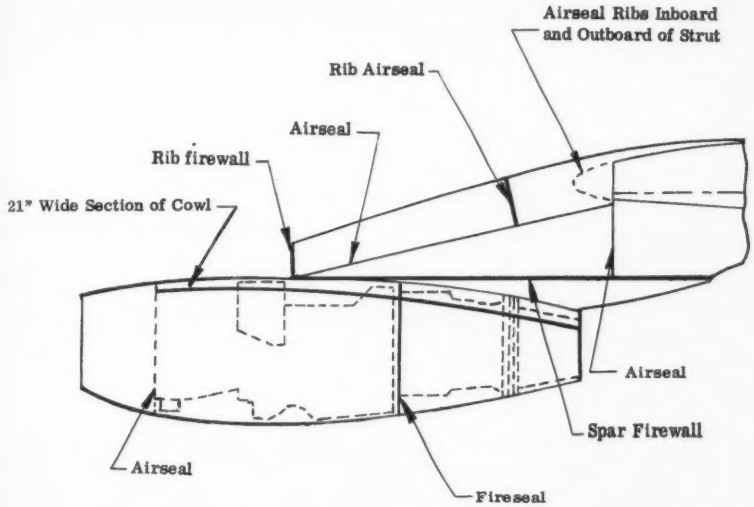
The air transport industry at that time was based to a large degree on twin-engined aircraft. Each powerplant in the aircraft combined fuel, oil, electrical and exhaust systems in an aluminum alloy nacelle, mounted in an aluminum alloy wing. The aircraft were obviously the safest that could be built at the time — but, in many instances, fire-resistant components did not even exist. As a result almost any overheat or small fire could rapidly develop into a major fire and any major fire could rapidly destroy the integrity of the wing and the airplane.

The need then was for immediate detection (within 3 seconds) and no great effort was made to discriminate between overheat and fire because the first could speedily develop into the second.

This lack of resistance to damage by fire was not peculiar to those aircraft. The wing-mounted powerplant of a multi-engined aircraft built in the middle 40's failed structurally in a full-scale ground fire test in nineteen sec-

Some new jet transports, as represented by this prototype model of the Boeing 707, have their powerplants in pods hung beneath the wing. This arrangement offers advantages in that an in-flight engine fire does not expose the wing to flame attack and failure.

Piston engine fires in early transports were capable of causing severe structural damage to the nacelle and adjacent wing structures resulting often in engine mount or wing failure. These views are of a test fire at the Civil Aeronautics Administration (now Federal Aviation Agency) Technical Development Center in Indianapolis which can be credited with much of the technical advance made in flight fire safety. (See July 1948 Quarterly.)



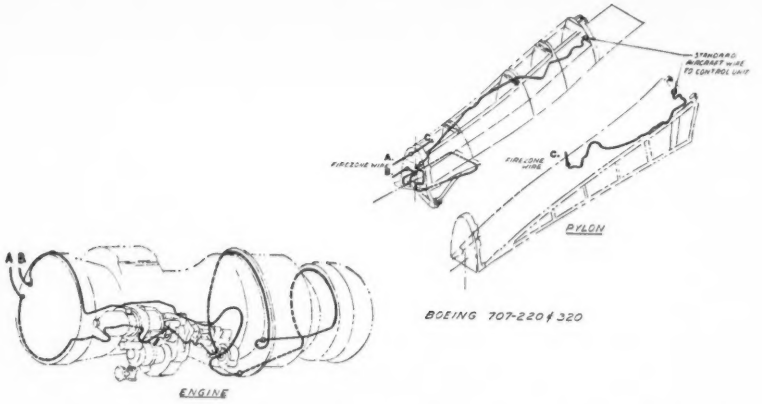
This is the powerplant pod and pylon on the Boeing 707. Note the fireseal and firewalls designed to contain any fire which might develop in the turbine engine. The concept here is first to provide isolation of the fire zones to prevent extension of any fire and tests have indicated this "power package" can withstand a fire for more than 9 minutes instead of a few seconds as for the old piston engine installations.

onds. Reports of flight fires indicated that powerplants could be burned off in as little as eleven seconds. All this meant that basically a detector capable of registering any overheat condition should operate in an absolute minimum of time and that the warning "FIRE" was, or shortly would be, correct.

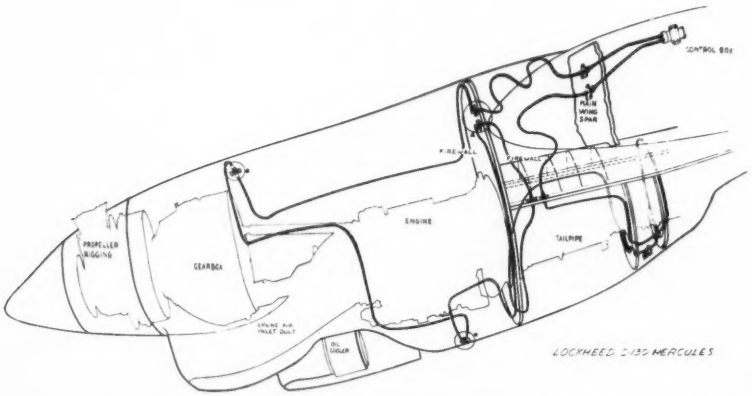
As a result of general state of the art advances, the level of aircraft fire prevention and fire protection improved slowly but steadily throughout the 1940's. Improved design from the fire standpoint and the use of materials of increased fire resistance were becoming more and more evident at the time that the turbine engine entered the field. Those improvements, combined with the turbine engine and the strut-mounted powerplant, have had a marked effect on fire hazards. Although aircraft speeds were increasing, airflows through the powerplant compartments were decreasing. On the other hand, engine compartment temperatures have risen steadily from the 450°F in the early transports to 900°F and higher for many turbine engine installations. Surrounding structure has increased in heat (and fire) resistance. This all means that many minor overheats can be (and are) lived with, but fire is still unacceptable. Thus the difference between fire and overheat becomes real in modern-day aircraft.

Present Practices

In spite of the general state of the art advances, the earliest fire detecting system philosophy still persists. We continue to label warning indicators "FIRE" when any heat source which produces temperatures higher than the relatively low detector set point actuates the detector. "FIRE" is the warning given by many thermal detectors when it is known that the difference between fire and overheat is critical.



A schematic diagram of a continuous type fire detection system in a Boeing 707 turbine engine and pylon. The designations A, B and C indicate separate circuits. Mr. Hansberry calls for re-evaluating the needs and purposes of such systems.



Another typical continuous detection system installed in a Lockheed C-130 powerplant. This type system as presently installed cannot distinguish between an "overheat" condition and an actual "fire" but there is no reason why this cannot be done by proper engineering attention to the technical details involved.

Generally, all fires are overheats, but all overheats *are not* fires. Fire is one of the major sources of overheat in an aircraft powerplant, but it is definitely not an exclusive source. Both military and civil experiences have shown that malfunctioning electrical and mechanical equipment, as well as leakage from heated air ducts and exhaust system joints, are frequent sources of overheat, and possibly, incipient fires. Even fire can be of two types; flame escaping from normal paths through an engine, or the fire external to the engine proper.

At the moment, there are no flight approved, aircraft powerplant detectors available which will detect flame but ignore temperature. Many groups, including Fenwal, Incorporated, are working on such detectors, but no such device has been sufficiently seasoned to be used in a primary aircraft safety system. There are, however, well-proven unit and continuous overheat detectors available for immediate use. Therefore, at the moment, we rely primarily on the overheat detector.

Present practices require the speed of detector response to be the same at an operating temperature of 1000°F as it used to be at 500°F. We can get that speed — but we pay a price. The price is paid by reducing the mass of the detector or by using devices which vary rate of rise temperature response. The reduction of mass unfortunately reduces the strength and has a definite effect on reliability. Incorporation of biasing devices adds complexity to overcome basic system shortcomings with resultant adverse effect on reliability, as has been evidenced by frequent problems in the past.

Present day malfunctions occur because detectors and systems are damaged by the manhandling they get in maintenance. Making a detector tough enough to resist damage when a heavy cowl is slammed closed on it is incompatible with the speed of response required. Malfunctions are also provided by setting detectors within a few hundred degrees of the "nominal" maximum temperature of a zone. In a so-called 250°F zone the detector would be set no higher than 450°F. Certainly no fire is required to trigger a detector set at 450°F, but that is the signal given when the detector operates. It might be interesting to note at this point that the term "zone temperature" is, in most instances, an illusion. What is that temperature in a volume where studies have shown variations in temperature from 150°F at one point to more than 700°F at another, under normal operating conditions?

Many so-called "false" alarms are false in the sense that no fire existed, but are unavoidable, as the temperature at the detector exceeded the detector set point, without the presence of fire. These are the most difficult "false" alarms to find and correct. The basic question is what was false? — the basis on which the detector was installed, or the detector warning itself.

Briefly, we have a relatively simple device that operates when exposed to a given set of conditions. Properly installed, the device is exposed to those conditions only when a suitable warning is required. If those conditions occur when a warning is *not* required, then the installation is at fault. If the warning indicator reads "FIRE" when it should read "OVERHEAT," then the "false" part of the alarm results from the label, not the detector.

One of the severest criticisms of existing airborne fire detection systems is found in the military pilot's instructions where he is consistently cautioned to check any fire warning before he initiates action. Our basic objective should be to make this system so reliable that a man can stake his life on it, which he must do in many instances.

Discussion

A change in thinking will be required to take advantage of the improvements which have been made in aircraft over the last eighteen years. Although fire was, is and will be for a long time a real problem in the air, we have reached the stage when we should evaluate the hazards we are fighting and strive harder for reliability, even at the cost of supersensitivity.

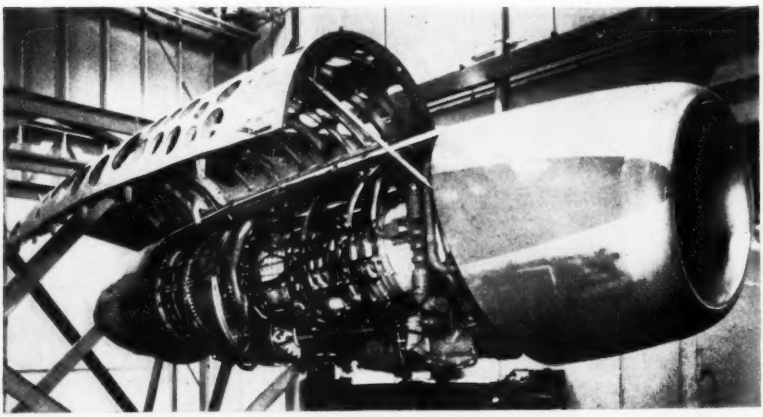
One basic change of concept suggested is to provide overheat protection for critical structure and components rather than, or in addition to, the present systems which give alarms on a general fire. Such a concept would envision systems engineered on an individual basis rather than a rule of thumb. Individual hazards would be evaluated

and critical regions given primary and complete protection. Known temperature limits of critical structure, for example, should determine the setting of a detector on or near that structure, not the normal ambient air temperature.

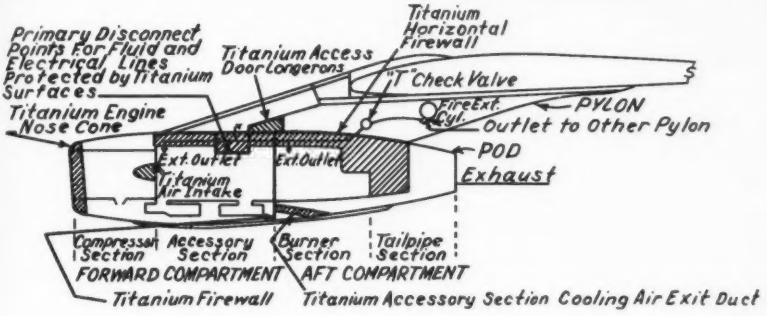
A second concept change would be to examine the exact speed of response necessary in a particular installation. The requirements of the DC-3 in 1940 are not necessarily identical with those of the DC-8 today. The DC-8 is far less susceptible to immediate critical fire damage than was the DC-3. Another example could compare the B-29 with the 707. In the early B-29, an essentially all aluminum nacelle was hung on an aluminum wing. Fire detection was required in five seconds and rightfully, as the powerplant support structure could be destroyed by fire within 20 seconds. The modern strut-mounted 707 powerplant has been shown to be capable of resisting fire for more than 9 minutes. Is the warning within 5 seconds still so necessary? Our detector philosophy does not recognize any difference between the old and the new. It should. As an example, we should be in a position to trade more ruggedness and reliability for a little more response time. This does not mean to suggest that speed is not desirable. It means that when speed and reliability are in conflict, reliability should take preference, particularly when the need for speed is decreasing.

A third concept change involves calling signals what they are, not what they might be. A warning, operated by a thermal detector which is set to trigger within 100° to 200°F of maximum normal temperatures should warn "OVERHEAT." Only true flame detectors, or thermal detectors operating at substantially higher temperatures should warn "FIRE."

As an example, take our zone with a maximum normal ambient of 250°F. An overheat detector should operate, say, between 350°F and 450°F depending on the degree of overheat permissible. A thermal type *fire* detector should trigger at, say, 900° to 1000°F, depending on the temperature at which the weakest critical structure or control component can be damaged. Perhaps a reliable system, providing warning at two temperature levels would give the pilot all necessary information. Such equipment is available.



A typical turbine engine. This engine will power the Convair 880, one of the three new U. S. jet transports expected to be in service by 1960.



Pod and pylon configuration on the Convair 880 shows how fire zones are segregated by titanium firewalls.

New Design Concept

1. Make the primary detecting system consideration be the protection of regions where known temperature conditions can damage or destroy basic structure or control equipment.

2. Determine locations at which specific temperatures should not be exceeded without warning.

3. Establish detector set points on the basis of temperatures which can damage adjacent basic structure or equipment, not on variable and inconsistent ambient air temperatures.

4. Determine the speed of response which must be attained if warning is to be given in sufficient time to be useful. Basic reliability may be of far more value than "the quicker, the better."

5. Emphasize basic reliability rather than multiple systems in which both systems are required to operate simultaneously to get a warning.

6. Make the secondary detecting system consideration be the protection of entire powerplant from a general fire.

7. Make detectors reliable by removing gimmicks. Get rid of devices to "soup up" detector speed and supersensitivity. Eliminate adjustability from all systems except those in experimental aircraft. Drive for definite set points, ruggedness and reliability.

8. Make detector installations reliable by calling signals what they actually represent. Overheat means the temperature is higher than it should be; fire means that combustion is taking place where it should not.

9. Develop a means for pilot or crew presentation which will be conducive to considered judgment and action. Possibly flashing the word "FIRE" at the crew is not the best method.

10. Fundamentally, give the pilot enough reliable information to enable him to make an intelligent decision.

AUTHOR'S NOTE: The concepts advanced in this paper are concerned only with the proper use of available equipment in newly-designed aircraft powerplants. More advanced fire detecting equipment and development of equipment to prevent fire are concepts which should be explored and discussed as separate subjects.

The FM Construction Materials Calorimeter

By Norman J. Thompson and E. W. Cousins*

Factory Mutual Laboratories

The Factory Mutual Construction Materials Calorimeter was developed to provide a reasonably accurate and consistent method of measuring the combustibility of construction materials in the range between those entirely noncombustible and common combustible materials such as wooden boards or planks. The objective was to classify materials or composite constructions with respect to potential property damage when combustion originates from a local exposure. The apparatus is *not* intended to measure rates of flame spread to assess the hazard of such materials in terms of safety to life.

Background

This development was given impetus by a disastrous industrial plant fire in 1953 involving an insulated roof deck construction in which vegetable fiberboard was bonded by means of asphalt to a steel deck. Following a series of large scale tests conducted by the Factory Mutual Laboratories in cooperation with the Metal Roof Deck Technical Institute, Factory Mutual underwriters and engineers placed roof decks in two categories, Class I and Class II.

Class I roof deck constructions were defined as assemblies whose combustibility had been reduced to such a degree that there would be only a small probability of any fire exposure sufficient to bring about extensively spreading high temperatures in a normally noncombustible occupancy. The limit of Class I combustibility was defined as any construction behaving the same under fire exposure conditions as a standard insulated metal deck with vegetable fiberboard mechanically fastened to a steel deck with no combustible bonding materials. Class II compositions are any that exceed the combustibility of Class I.

The really dangerous fire with respect to extensive property damage is the fire that spreads continuously with a *sustained* heat release. Whether or not a fire will spread does not depend on any single property of the material such as ignition temperature, heat content, or ignition susceptibility, but instead is a matter of heat balance. If the rate of heat liberation from combustion exceeds the rate of heat losses by radiation, conduction and convection, the fire will grow; if there is no excess heat, the fire will go out.

In a fire involving the underside of a roof, products of combustion and any excess heat will flow outwardly under the roof and thus preheat material ahead of the fire front. Consequently, a test method which will measure the amount of excess heat production from a fire on the underside of a horizontal panel will give a measure of the probability of a spreading fire developing in the construction under test.

In developing our Construction Materials Calorimeter test method we had as our objective the actual measurement of the amount of heat and of the rate at which it is released into a building. These two factors determine the extent to which building structural members will sustain fire damage other than the superficial damage caused by smoke and fumes. Except for action as a communicant of ignition, mere surface flame spread or heat release rates of only 1- or 2-minute durations are not important

*Norman J. Thompson is Director of the Factory Mutual Laboratories. E. W. Cousins is the Laboratories' Chief Research Engineer.

with respect to any serious building damage. In order to evaluate accurately the sustained heat release from combustibles under the sample surface and to have the identical heat loss by conduction, the sample must be an exact duplicate of the construction to be evaluated, with no insulating backing or support above the sample.

Test methods used heretofore have attempted to evaluate fuel contributed by merely comparing the time-temperature curves achieved with different materials. It can be shown mathematically and by actual test that the area under a time-temperature curve is not the correct approach, since the flue temperature at any particular time is a function both of furnace temperature and time. For example, it should be obvious, in view of differences in both radiation and thermal conduction losses, that a flue temperature difference of 100° F with a furnace wall temperature of 500° F at 5 minutes would have a significance entirely different than if it had occurred at a furnace temperature of 1000° F at 20 minutes.

It was necessary to relate the Calorimeter results to field conditions to permit an interpretation in terms of what would happen in an actual fire. To this end we were fortunate in having a concurrent large-scale metal roof deck test program in progress while the Calorimeter apparatus was being developed. We were thus able to set heat release rate and duration criteria realistically on the basis of results of tests on our 100 foot long by 20 foot wide Roof Deck Test Structure.*

How The Calorimeter Operates

The principle of operation of the Calorimeter is the method of direct substitution. The test panel, which is a sample of the whole construction to be tested, is used as the horizontal cover of a liquid fuel-fired test furnace. The top of the sample is exposed to the atmosphere. The flue temperature versus the time curve resulting from the exposure burners and combustion of the panel is recorded. Tests are continued until significant contribution from the sample has ceased. For most materials this would be 30 minutes or less. To measure the excess heat produced by the sample, the same procedure is followed with a noncombustible furnace cover beneath which fuel of a known heat content is added through auxiliary burners at measured rates to reproduce the flue temperature-time curve produced by the sample. If all other conditions are the same, the heat added through the auxiliary burners equals the excess heat produced by the sample.

Operational Controls

Although the principle of operation is simple, many precautions must be taken in the design and operation of the furnace and auxiliary equipment to make sure that the assumption of equality of conditions is justified:

1. The flue temperatures must be taken to ensure a true average.

2. Rate of fuel flow to the exposure burners must be metered and carefully controlled to ensure that the exposure is the same in both test and evaluations.

3. Air for combustion must be constant throughout both runs and, since it serves as the heat transfer medium, its mass-rate of flow must be independent of the ambient temperature.

4. The flame from the auxiliary burners must be in the same location and have the same luminosity as the flame from the panel.

5. Initial furnace conditions must be the same for both the test and the evaluation; that is, the initial furnace temperatures must be equal, and also the temperature gradient in the furnace walls must be the same in both cases.

6. Combustion of the exposure fuel and of the evaluation fuel within reasonable limits must be complete. This

*See photo page 219.

imposes a limitation on the maximum heat contribution which can be evaluated.

In addition to the precautions necessary to make the test valid, some other factors must be considered to make the apparatus sufficiently sensitive:

1. The furnace lining should be a good heat insulator and have a low heat capacity.

2. Excess combustion air should be held to the minimum needed to support complete combustion of a sample at the greatest rate to be measured.

Description of Apparatus

The appearance of the Calorimeter furnace from the firing end is shown in Figure 1. Dimensions and construction details are shown in Figure 2. Samples are usually fabricated in 4½-foot by 5-foot steel angle frames with a 4-foot-square area exposed to the interior of the furnace. In Figure 1, a sample suspended by chains will be seen ready for lowering into place. The fuel is supplied to the main exposure burners at a constant rate in order to ensure a completely reproducible exposure. Figure 3 shows the fuel piping and controls.

The combustion air is always preheated to 100°F to make the mass-rate of supply independent of ambient temperature. Air flow in the supply duct is measured, and an orifice installed in the blower inlet gives a flow which provides air for the exposure burners and a sufficient excess to permit a maximum sample combustion rate of approximately 1,100 British thermal units per minute per square foot of sample.

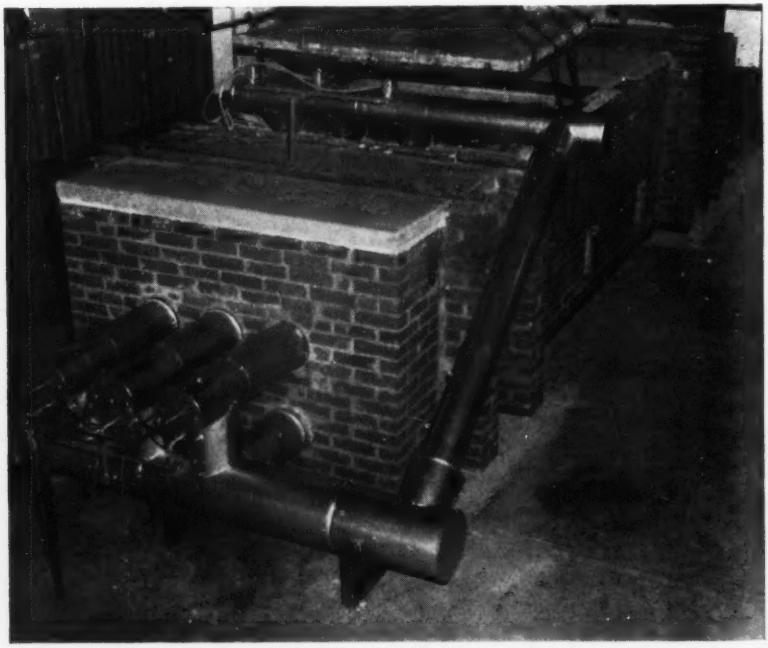


Figure 1. The FM Construction Materials Calorimeter from the firing end. The construction sample to be tested is here shown suspended by chains ready for lowering into place.

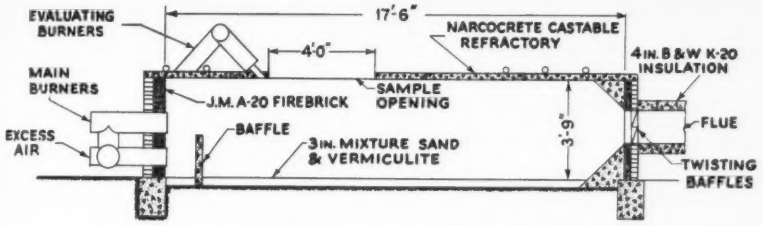


Figure 2. Dimensions and construction details of the Calorimeter.

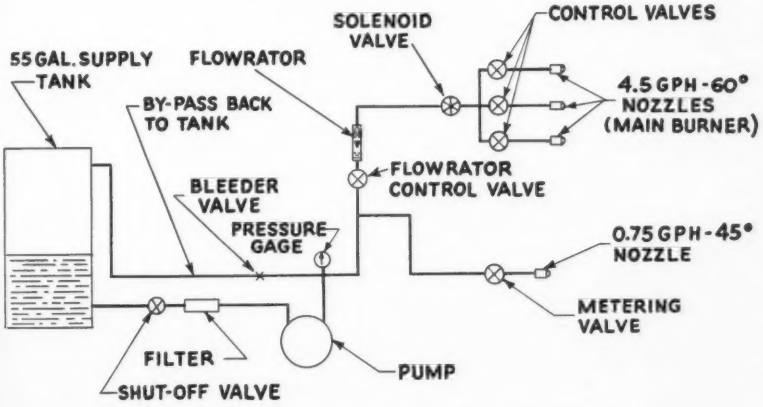


Figure 3. Fuel piping and controls for the Calorimeter.

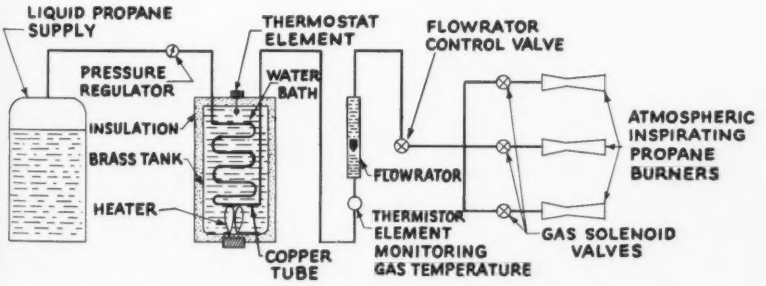


Figure 4. Diagrammatic arrangement of propane fuel controls.

Thermocouples are located in the 16-inch flue on four radii at right angles so that the temperatures are measured at four locations in each of three equal concentric areas. Since reading 12 temperatures from the recorder charts and averaging them for each time point is tedious and time consuming, the readings are averaged automatically by connecting the thermocouples in series to sum them and then dividing electrically before recording. The series connection

was chosen rather than parallel so that failure of a thermocouple would be clearly and immediately apparent. To prevent loss of a test from failure of a single thermocouple, a second set of couples is installed 4 inches behind the first, displaced 45° from them.

Propane is used as the evaluating fuel. It is supplied to the flow meter at constant temperature and pressure through the arrangement shown diagrammatically on Figure 4 so that any given flow meter reading always gives the same mass-rate of flow regardless of ambient conditions.

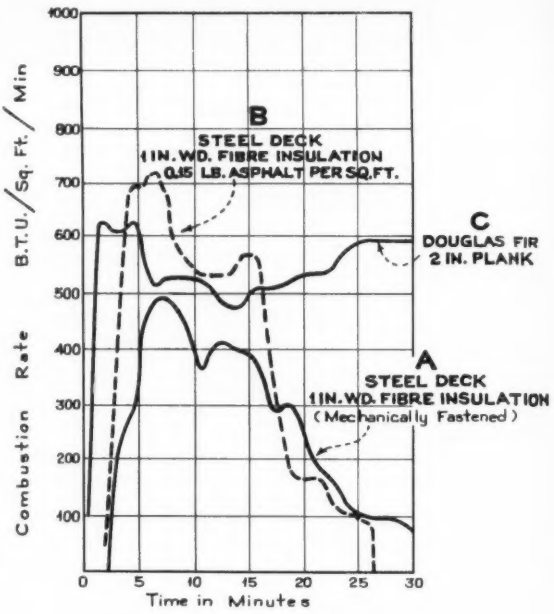


Figure 6. Examples of Test Results.

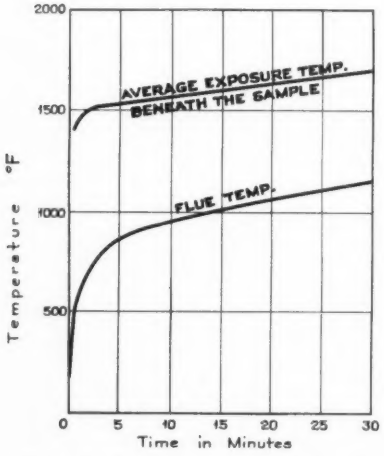


Figure 5. Top line shows temperatures to which samples are exposed in the Calorimeter, averaged at thermocouples located ½ inch below the sample. Bottom line shows flue temperatures developed with a noncombustible sample at the standard firing rate.

The temperatures to which the samples are exposed are shown on Figure 5. The temperatures plotted are taken at the standard firing rate, and represent the average of five thermocouples located ½ inch below a refractory cover over the sample opening: two near the leading edge, two near the trailing edge, and one at the center of the opening. This exposure is entirely arbitrary, and is very roughly equivalent to the standard ASTM fire resistance test exposure compressed into less than one-half the usual time. With a combustible sample the exposure temperatures are increased by the heat liberated by the sample as would be the case in a fire. The same graph also shows the flue temperatures developed by the standard firing rate with a noncombustible sample.

Sample Results With The Calorimeter

Some results obtained with the Calorimeter are shown in Figures 6 and 7.

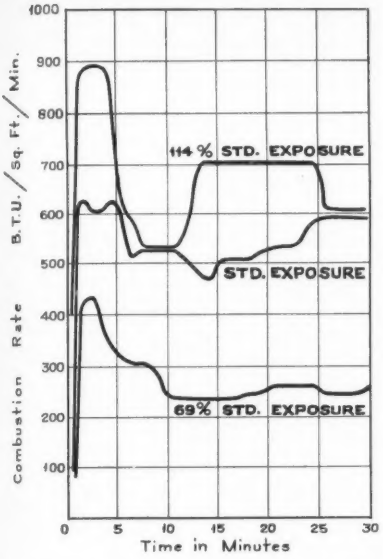


Figure 7. Results indicating effect of exposure on Douglas fir heat output.

Combustion rate for a Class I roof deck composed of 1 inch of vegetable fiber insulation mechanically fastened to steel deck is shown by curve A in Figure 6; curve B shows the combustion rate for the same insulation secured to the deck by a mopping of 0.15 pound of asphalt per square foot. Both tests were at the exposure rate shown on Figure 5.

Comparison of curves A and B shows that the addition of 0.15 pounds of asphalt per square foot increases the combustion rate very sharply. Curve B peaks at 720 British thermal units per square foot per minute. If the total heat outputs for each sample are summed over a significant interval of time such as 20 minutes, the difference between samples exceeds the heat attributable to the asphalt alone. This is because the asphalt vapors burning directly beneath the deck increase the effective exposure to the fiber insulation, which contributes at a greater rate than it does with no asphalt present.

The effect of variation in the exposure is shown on Figure 7. Here three curves represent heat output from 2-inch-thick Douglas fir plank at three different firing rates. It is a characteristic of the combustion of a wood sample that, following an initial surface fire, the resulting layer of charcoal serves as an insulating layer to slow down the rate at which heat penetrates into the remaining fuel. Thus, all three curves on Figure 7 show a rapid initial rise to an early peak followed by a decline as the insulating effect of the charcoal increases. These curves also show the necessity of careful regulation of exposure, since the fuel contribution rates of all combustible materials depend on both the nature of the material *and the exposure.*

Under standard exposure and 69 per cent standard exposure, there is a gradual rise in rate as the interior of the furnace grows hotter. The second rapid rise in the 114 per cent curve was probably due in part to charcoal flaking off, coupled with the effect of the more intense exposure.

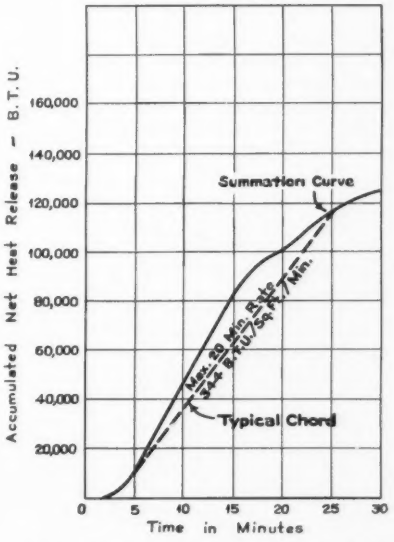


Figure 8. How FM interprets the results of tests. The summation curve and chord are explained in the text.

Results are processed by first constructing a summation curve as shown in Figure 8. This curve represents the various rates, multiplied by their respective durations, summed throughout the test. Thus, referring to the curve, at 20 minutes this particular sample had released a total of 100,000 British thermal units within the furnace.

Figure 8 also shows a typical "chord" to the curve, this particular chord representing the maximum 20-minute rate for the sample, occurring between 5 minutes and 25 minutes. The rate is determined as follows:

Heat release: 118,000 − 8,000
= 110,000 British thermal units

Time interval: 20 minutes

Area of sample: 16 square feet

$$\text{Rate of heat release: } \frac{110{,}000}{20 \times 16}$$

= 344 British thermal units per square foot per minute.

Similarly, by a process of cut and try, maximum slopes can be found for chords spanning 3 minutes, 5 minutes, 10 minutes, etc. Results are expressed as maximum rates achieved for these various time intervals.

Conclusion

Development of the Factory Mutual Construction Materials Calorimeter test method has now been completed and the apparatus is in constant use, both in connection with approval of products and in the development of products having reduced combustibility. Although the method was developed primarily to measure the net heat contributed by constructions installed in a horizontal plane, with the exposure only on the underside, the apparatus may also be used to evaluate materials intended for sidewall construction (in a vertical plane). Another practical use of the apparatus is in testing the effectiveness of fire retardant treatments as to their ability to reduce the rate of heat liberation.

The reproducibility of results has been thoroughly checked and is entirely satisfactory. Thus, loss prevention interests, material manufacturers, and code authorities have at their disposal a means of measuring in precise physical terms the fire hazard of materials with respect to potential property damage.

Acknowledgment

The authors wish to acknowledge the contributions of Mr. William E. Durkee, who served as Project Engineer during development of the apparatus.

Six Items for Dwelling Construction Codes

By Richard E. Stevens, Assistant Technical Secretary

National Fire Protection Association

Why should dwelling construction codes have provisions for fire safety? Why add expense to dwelling construction costs by asking for fire protection? Why are fire safety provisions in dwelling construction codes any more necessary now than 100 years ago?

These are three questions that might be asked by construction people and which can be answered easily and factually. Let's consider the first question. Why should dwelling construction codes have provisions for fire safety? The answer lies in the fire record. About 6,400 people die in dwelling fires annually. Many of these deaths might have been prevented with proper dwelling construction methods and materials.

Why add expense to dwelling construction costs by asking for fire protection? That question might be answered with a counter question. What is a human life worth? Fire safety in construction need not add much, if any, expense. An extra door, some firestopping, the difference in cost in dry wall construction between gypsum wallboard and pressed paperboard are some items that might add a few dollars. But many homeowners are willing to pay up to $700 for a fire alarm system and certainly would be happy to absorb the few dollars needed to build fire safety into their homes. Building a chimney correctly, installing a furnace with proper clearances, exhausting a kitchen ventilating fan to the outside instead of the attic are just a few fire safety features that are included in the price of a house but which are not being done. Codes, carefully administered and enforced, would assure the homebuyer of getting his money's worth in such cases.

Now, the last question. Why are fire safety provisions in dwelling construction codes any more necessary now than 100 years ago? Fire safety provisions are not any more necessary now than 100 years ago. The loss of life from fire in dwellings was relatively just as high 100 years ago as it is today, but fire protection has "come of age." We do not consider a fatal fire "an act of God" anymore. We know how to prevent fire and how to control it. Let's use that knowledge to save lives.

To accentuate the need for building code provisions on fire safety for dwellings, I have selected some typical ex-

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This article by Mr. Stevens was presented as a paper at the 1958 NFPA Fall Conference in Pittsburgh, November 17–19, 1958. Associated items on the program were the following.

A paper by Horatio Bond, NFPA Chief Engineer, in which he developed the requirements for public fire department protection for the safeguarding of residential areas, indicating limits of building area and separation.

A paper by Everett W. Fowler, Chief Engineer of the National Board of Fire Underwriters in which he described and discussed the provisions of the National Building Code applying to residential construction, indicating their reasonableness.

A paper by Milton W. Smithman, Assistant Director, Construction Department, National Association of Home Builders, in which he discussed the additional cost of home building to comply with the diverse requirements of local building codes which contain requirements beyond National Standards. He indicated the reasonableness of the requirements of the National Building Code, the Uniform Building Code, the Basic Building Code and the Southern Standard Building Code.

amples of cases from the NFPA Fire Record files to show the need for these provisions and to provide a few possible answers to some deficiencies which result in loss of life by fire.

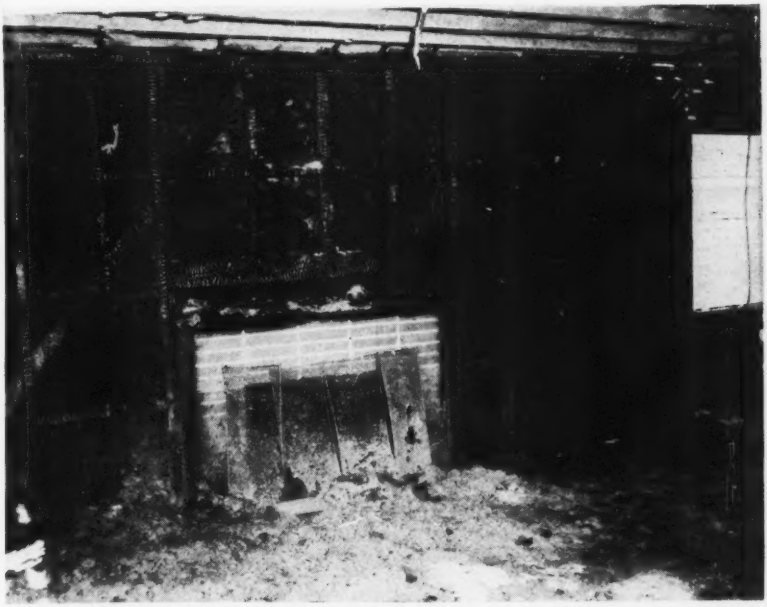
Highly Combustible Interior Finish

Photo No. 1 shows the aftermath of a fire in a dwelling that occurred in San Diego, California, on April 10, 1958, and resulted in the death of three children ages one and one-half to nine years. The mother of the family had placed a chicken in the broiler compartment of the kitchen range before she and her husband relaxed in the living room and dozed. The husband, awakened by the smell of smoke, went into the kitchen, opened the broiler and was met with a flash of fire. He shut off the gas, grabbed a pan of water and threw it into the broiler. Unfortunately, as would be expected, this procedure caused the burning grease to splatter over the pressed paperboard sheathed walls of the kitchen. Unable to control the fire, the husband awakened his wife who fled via the front entrance with her youngest child. He was able to push five children through an exterior bedroom window before he was driven outside by the rapidly spreading fire. He then attempted to rescue three other children through a bedroom window from the outside but was unsuccessful. According to reports received by the NFPA office, the fire spread very rapidly over the pressed paperboard interior finish which delaminated quickly.

Photo No. 2 shows the fire effects of the interior of a new dwelling sheathed with an imported plywood. This was one of a series of fast-spreading fires which occurred in California in 1957, all involving the same imported plywood. The plywood delaminated quickly and was consumed rapidly in each of the fires. It has been estimated that the flame spread rating was well over 300. (See NFPA No. 255 and Section 44 of NFPA No. 101.) Continued use of this and other interior finishes having a high flame spread rating was stopped when local fire department people, fire protection engineers and building inspectors brought about local legislation prohibiting the use of interior finishes possessing flame spread characteristics of over 250. Photo No. 3 shows a section of the same dwelling where gypsum wallboard was used. Note that where the wallboard has been removed, the wall studs are not even charred. Here, then, is one factor to be considered in building codes; that is, the use of highly combustible interior finishes.

San Diego Fire Marshal

Photo No. 1



Santa Clara County Fire Marshal **Photo No. 2.**

Santa Clara County Fire Marshal **Photo No. 3.**

Fire Dept., Yuba City

Photo No. 4.

Adequate Exit Regulations

Photo No. 4 shows the interior of a dwelling which was involved in a fatal fire on April 1, 1958, in Yuba City, California. Four children, ages six months to five years died in this fire. The mother and one child were rescued by firemen but the child died later in the hospital. According to reports received at the NFPA office, there was no clearance between the vent connector on the gas heater, shown in the photo, and the knotty pine interior sheathing. It was at this point that the fire originated. Note that the vent connector is also improperly installed because it drops down from the heater and enters the vent at a point lower than the vent connector outlet at the heater. The factors in this fire, pertinent to this discussion, however, involved not only the installation of the gas heater but also the location of the heater which happened to be between the occupants of the apartment and the only exit to the exterior. The door leading to the outside from the apartment is to the left of the window shown in Photo No. 4. This then becomes a case where a space heater was installed where it could, and did, block the only means of escape. Another feature about the loss of life in this fire involved the fact that there were apparently no doors on any of the bedrooms. This will be discussed later.

Photo No. 5 shows a new home which fortunately has not, to my knowledge, been involved in fire but is shown merely to point out the size of the windows. Frequently in dwelling fires, the windows become the only means of egress from bedrooms and when they are not useable as exits, tragedy results. Photo No. 6, a rear view of the same house, shows that these windows are on more than two sides of the house.

Photo No. 5.

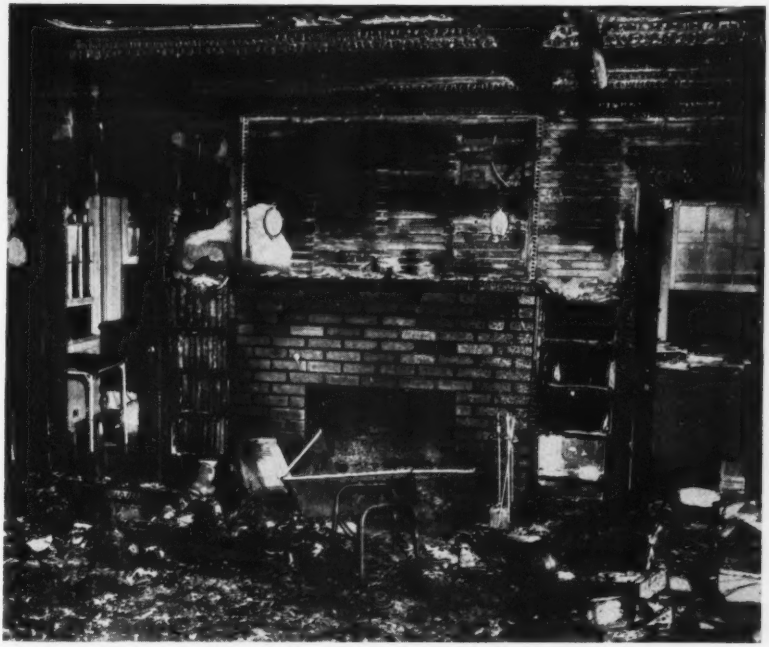
Photo No. 6.

These two cases point out the need for code requirements on exits for dwellings, particularly from sleeping areas. The fact that windows may be considered as emergency exits indicates a need for regulations on their size, location, and construction.

Importance of Doors

The next item requiring attention is the need for the installation of doors in dwellings. Modern practice is leading towards the elimination of doors or the use of folding doors of various kinds of material that do not fit tightly and have no significant fire resistance. Many fatal dwelling fire reports indicate that a door installed in a proper location, of the proper type and closed at the time of fire could have prevented a great many fatalities.

For example, this Photo No. 7 shows the interior of a dwelling in Greenwich,



United Press

Photo No. 7.

Connecticut. The fire occurred on March 8, 1958, and originated in the living room shown in the photo. Smoker's carelessness and the cord on the television set are two suggested causes. The father of the household had been watching television and had fallen asleep at the time the fire occurred. He awoke and was able to dive through a window and escape, but the fire spread quickly up the open stairway to the second floor bedrooms and although his wife was awakened in time to push her 13-year-old daughter out a window to a porch roof, she was overcome before she could lead her other two teen-age children to safety. All three were asphyxiated. If there had been a closed door at the bottom or top of the stairway this certainly would have retarded the smoke and fire for a sufficient length of time for the father, who had already escaped, to get to the porch roof and rescue the entire family.

Photo No. 8.

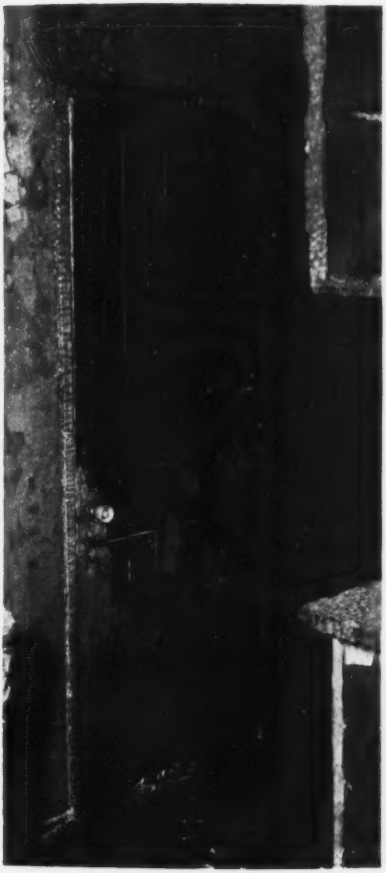
The problem of the installation of doors is, in my opinion, becoming more and more acute. Photo No. 8 shows a tri-level home in the price range of $20,000 to $30,000. This photograph is shown only to indicate that this home has quality and that there are in fact 4 levels in the house. Undoubtedly, the builder is proud to have built it. Photo No. 9 shows a picture taken from the grade level of that house down the stairway to the basement level under the living room. Note the oil tank on the right and, as you can imagine, the

Photo No. 9.

Photo No. 10.

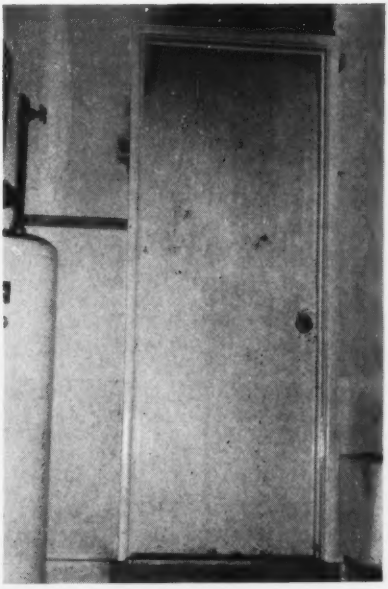
furnace is just to the left of the door but cannot be seen in this photograph. Photo No. 10 was taken from the level above (living room level) looking up the stairway to the floor where the bedrooms are located. In other words, there is no intervening door between the four floors in this new home.

What is the value of a door in a dwelling? In Photo No. 11 is shown a common solid core flush door that has been exposed to fire that gutted the interior of a dwelling. Photo No. 12 shows the same door on the unexposed side. Please note that there are no effects of



Santa Clara County Fire Marshal
Photo No. 11.

burning through the door and only small quantities of smoke were able to seep through due to the small crack at the top of the door. Photo No. 13 shows the exterior of the same dwelling. The front door was a flush door but *not* a solid core door. This door obviously burned through quite readily and although there is no way of knowing how much time elapsed before the door did burn through, the difference in fire behavior between the two types of doors is obvious.



Santa Clara County Fire Marshal
Photo No. 12.

Santa Clara County Fire Marshal
Photo No. 13.

United Press

Photo No. 14.

A solid core flush door is not an expensive item. In fact, the price differentiation between a solid core door and a hollow core door is a very few dollars. Fire protection people know the value of protecting vertical openings to limit smoke and fire spread. That principle applies to dwellings where life safety is all important just as much as it does to any other building.

Chimneys, Fireplaces and Flue Pipes

Photo No. 14 shows a fire in a dwelling in Quincy, Massachusetts, on March 7, 1958, that originated in a newly constructed recreation room in the basement. As in the fire in Yuba City, California (Photo No. 4), there was no clearance between the knotty pine paneling in the recreation room and the smoke pipe from the furnace which passed through one of the paneled partitions. The fire, of course, originated at this point. In spite of the fact that the stairway was open, the mother of the family grabbed two of her children, instructed an older child (seven years of age) to follow her and escaped from the second floor via the front door on the first floor. The seven-year-old child apparently became confused and lost his way in the smoke. His body was found on the stairway leading into the attic.

Another fire which I would like to call to your attention and of which I unfortunately do not have a photograph, occurred in Dedham, Massachusetts, on November 7, 1957, and originated in a new tri-level type home. In this fire a grandmother and her grandson died. An investigation after the fire revealed that the fireplace was built with only one thickness of brick at the rear and there was no clearance between this brick and the wood stud wall behind it. There had been a fire in the fireplace all day and ultimately the wood stud wall was ignited late in the evening while the parents of the child were next door

playing cards with neighbors. The grandmother and her grandson were asphyxiated before the fire was discovered by a neighbor who noticed the windows were blackened and called the fire department. These two cases point out other requirements which should appear in building codes, that is, the construction of chimneys and fireplaces and the installation of flue pipes.

Summary

Summing up quickly, let's review six basic provisions that should be included in building codes, specifically on dwelling construction as indicated by the cases just shown and others not shown but equally as important:

(1) limitations on the fire spread characteristics of interior finish

(2) provisions for adequate unobstructed exits, particularly from sleeping quarters, including minimum sizes for windows where they may serve as emergency exits

(3) the installation of doors where needed to cut off sleeping areas from the rest of the house

(4) the installation of firestopping

(5) requirements for the proper construction of chimneys, flues and fireplaces

(6) limitations on the use of wood shingles for roof coverings.

These cases do not cover all of the fire safety considerations that might be included in building codes for the construction of dwellings. Nor do they include the many features not considered a part of the actual building structure such as wiring and heating systems.

Building codes seem to be aimed primarily at protecting the public against buying a house that might fall down. Those of you who may have reviewed typical codes undoubtedly found that the large proportion of the code is devoted to the maximum allowable span for joists and rafters of various sizes and spacings, the size and spacing of studs, the thickness of sheathing and foundation walls and even the number and size of nails that must be used on all the component parts. All this may well be necessary to assure that a house will not collapse. But how many people are killed annually from collapsing houses as compared to those who die from fires in homes?

It seems that the balance of code provisions is weighted too heavily on structural stability. Let's right the balance with more weight on fire safety.

Land Shipping Radioactive Material

By D. E. Patterson and R. V. Batie

Safety and Fire Protection Branch, Idaho Operations Office

U. S. Atomic Energy Commission

Already large quantities of radioactive materials are being handled in shipping. With the advent of civilian nuclear reactors and the widespread use of radioisotopes the volume will increase.

Containers

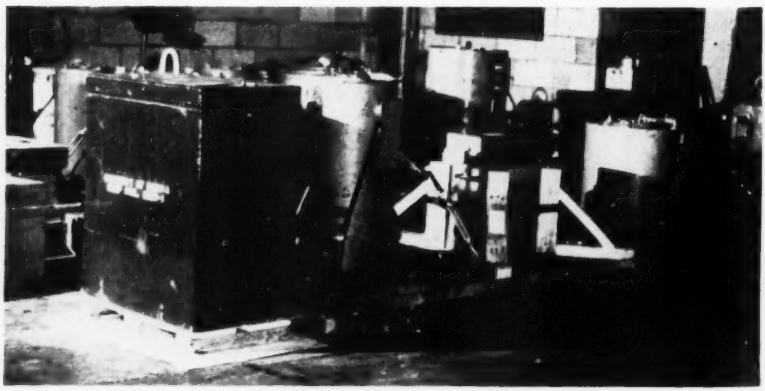
By definition, radioactive materials are substances which give off energy in all directions in the form of particles or rays. If sufficient of these emanations reach living persons or animals, they may cause various kinds of injury. The particles or rays can also damage physical materials which must be kept free from radiation, for example, photographic film.

This article is the substance of a paper presented by Mr. Batie at the 1958 conference at Germantown, Maryland, June 24–25, of safety and fire protection personnel of the Atomic Energy Commission and its contractors.

One of the locations now shipping considerable radioactive material is the Atomic Energy Commission's National Reactor Testing Station in Idaho. All shipments there are inspected and approved by the Idaho Operations Office, Health and Safety Division, before being released from the plants. This article outlines some of the problems experienced by members of this group in connection with assuring the safety of these shipments.

Contents of Shipments

Shipments of radioactive materials consist of radioisotopes in a wide variety of chemical compositions and all physical forms (liquid, solid, and gaseous). Particular isotopes, produced by irradiation of material in reactors, are shipped to users all over the country. Spent fuel elements are used in various facilities as high-level gamma radiation sources. Spent elements are also shipped



Containers in which radioactive materials are shipped are referred to as casks. The ones illustrated weigh from one to six tons each. Containers are heavy and frequently mounted on pallets to make it possible to move them with fork-lift trucks.

Shown are two casks for shipping radioactive materials, each weighing approximately seven tons. The cask on the right has a special frame so that it is held in a proper position. The frame is arranged so as to make it possible to tie the cask down in shipment.

to a chemical plant for processing to recover unused fuel and safely dispose of the radioactive waste. Shipments of the highly radioactive wastes are being made to plants which are experimenting with methods of recovering useable components. Other shipments consist of contaminated experimental equipment which is sent to other Atomic Energy Commission installations for tests.

The quantities of radioactive materials involved in these shipments range from trace amounts to more than one million curies. The chemical form, physical form, and quantity all affect the relative hazard of a shipment.

Number of Shipments

In the 1956–57 fiscal year ending June 30, 1957, the National Reactor Testing Station experienced approximately 2,000 shipments between various plants and the facilities on the site. There were 650 incoming items, and 646 items shipped to locations off-site; of the off-site shipments, 380 were moved under security escort. During this same period, the Safety and Fire Protection Branch inspected 450 vehicles used in connection with shipments.

Shipments are made under the rules of the Bureau of Explosives of the Association of American Railroads as promulgated for the United States Interstate Commerce Commission. These rules include: restrictions on quantities (curies) which may be shipped; radiation level external to the container; labeling to warn of the hazard; and a provision exempting the AEC from these regulations when authorized escorts accompany a shipment. However, despite this last rule, the AEC has established the ICC Regulations as its *minimum* safety standards.

Although limits are set by ICC on the quantity of radioactive material which can be sent in one shipment, exemptions can be obtained to ship material in excess of these limits. Each of these "excess curie" shipments must receive approval and a special permit from the

Bureau of Explosives. As part of their review the Bureau examines the design of each container and assigns a number to each container approved. "Excess curies" can mean anything from a few curies of material to an unlimited number. Many of the shipments to and from the National Reactor Testing Station are in the "excess curie" category, and it is here that the rules are vague and the problems greatest. As mentioned, each shipment must be treated on an individual basis.

The ICC regulations are not simple, and experience in shipping is very essential to interpret them properly. Evidence of this has been noted in a number of minor infractions of the ICC regulations occurring in shipments arriving at the site, although in no case has there been any incident of excessive exposure to radiation. Of the 485 commercial shipments, 22 were incorrectly sent as exempt; the container was too small in two instances, and in two others the container was damaged. An excess of curies (without Bureau of Explosives permit) was a factor in one case, and in nine cases there were, on the outside of the container, smears or contamination readings above the maximum permitted. In a number of other cases the container was incorrectly marked or the labels were incorrectly filled out.

This three-ton cask or container for handling radioactive material has a number of undesirable features. The bent lifting-ears are too big to be handled with an ordinary shackle, and they are too sharp for use with lifting cables. The narrow rail pallet is unsatisfactory for handling the container with a fork-lift truck.

Radiation diminishes very rapidly with the distance from the source, so that safety for living things and other materials is often accomplished simply by maintaining a safe distance.

This safety factor is useful in a good many cases where certain radioactive materials are prepared for shipment. The radioactive material in its container is set in the center of a framework, the dimensions of which are sufficient to provide whatever distance is required for safety. The frame is then placed in a carton, box, or can, which becomes the over-all shipping container.

For low-level radioactive material shipments where the health hazard is small, the Bureau of Explosives has approved wooden boxes, fiberboard boxes and drums, and metal drums. In determining whether to use combustible containers for these shipments, both the health hazard and value of the material must be considered. For example, items frequently transported long distances are the nonirradiated fuel assemblies for use in reactors. The usual shipping container for these is a well-constructed wood box with a combustible type packing material, chosen to enhance nuclear safety. Work is presently being done to develop a fire-resistive type container with a noncombustible packing.

For materials emitting radiation in substantial quantity, a shipping container would have to be very bulky in order to accomplish safety by air space separation alone. For such materials, a container of very dense material such as lead is necessary. The entire shipment is then encased additionally in

steel to prevent fire loss. These containers (called "casks") must be used with the "excess curie" shipments mentioned earlier.

Since these containers are for material exceeding the normal safeguard limitations, it is apparent that the Bureau of Explosives design requirements must be quite general. Casks therefore may vary greatly in size, shape, and weight; they are, of course, extremely heavy due to the necessary high density shielding.

Much more thought and study need to go into the designing of containers or casks suitable for handling shipments of radioactive material. Standard containers could be designed with adequate strength to resist mechanical injury, and adequate protection for the contents against damage from fire.

Deficiencies in Container Design

Currently, with the design of containers left to the option of many different people, the results often reflect a lack of consideration of shipping problems. The designers do not seem to understand that if the container is very bulky, or heavy, or both, special handling equipment must be employed. For example, it may be necessary to put the container on a pallet so that it can be handled by lift trucks. The weight of the container may be such that it has to be lifted from one place to another by means of cranes, and for this purpose means should be provided for attaching chains or cables. These means are often inadequate, and many designs of pallets for use on lift trucks are poor.

There are a number of other deficiencies in container design which need to be mentioned. For example, the method by which the container holding the radioactive material is closed may be unsatisfactory, or the container may have valve, drain plug, thermometer, and other extrusions which are so located as to be vulnerable to breakage in case of a transportation accident. Most of these problems result from designs to facilitate the cask-handling methods used in the plants. Following are some of the features which need to be considered in relation to shipping.

One type of cask in use has an aperture running completely through it with covers at each end. To load it, this cask is set, with the end plugs removed, against the reactor or shielded storage area from which the radioactive assemblies are to be taken. A handling tool is run through the container and hooked to the radioactive piece. The material to be loaded is pulled into the container, the tool is disengaged and removed, and the plugs are put back to close the container.

At present, such containers are used mainly for handling material within nuclear plants and are not often used in shipments for general transportation. As the volume of reactor work increases, however, increased use of this particular type of container is likely to be found on the roads and railroads.

Containers which require only one opening in order to insert and take out the radioactive material are the simplest. For materials of low radioactivity the loading and unloading can be done by the use of long-handled tools or tongs, since the substances involved

An example of poor rigging practice is this rail shipment made up somewhere else for delivery to the National Reactor Testing Station. Considerable movement of containers in transit took place in this case. Cables must be properly used to insure that they will hold a container properly in place. Many shipments were obviously prepared at locations where adequate experience in rigging cables was not available.

are safe enough to handle provided they are kept at proper distances.

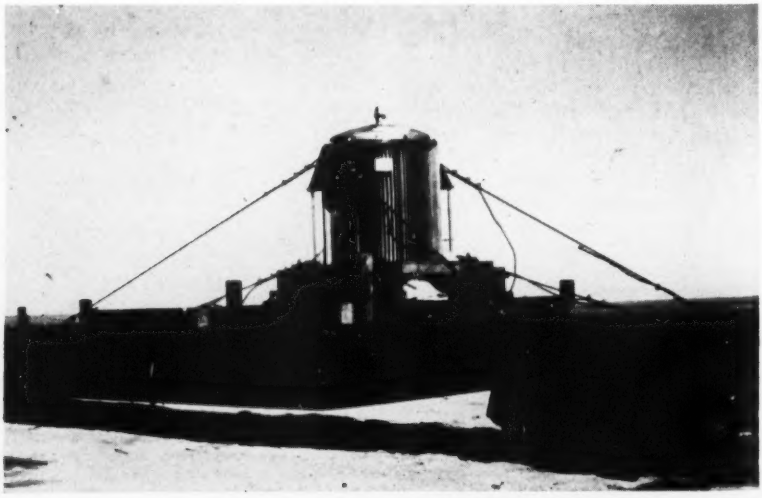
Containers of this type are also loaded and unloaded by being placed in a "hot cell" or in a pool of water. The hot cell is simply a space providing a radiation-shielding barrier between the radioactive material and the person who must do the loading and unloading. The actual handling of the material is done by remote-control manipulative apparatus.

Loading and unloading under water in a pool requires a method of removing the cover. For small casks it is sometimes a simple matter of using a long-handled lifting tool. In other cases a crane has to be hooked on to pull off the cover. Another technique is to have a special framework built into the pool. The cask is lowered into this. Rails extending from the cover catch on the frame, suspend the cover while the cask is lowered to the bottom of the pool. A piece to be inserted is then picked up with a handling tool and placed in the container, the cover is replaced, and the casks lifted above the pool.

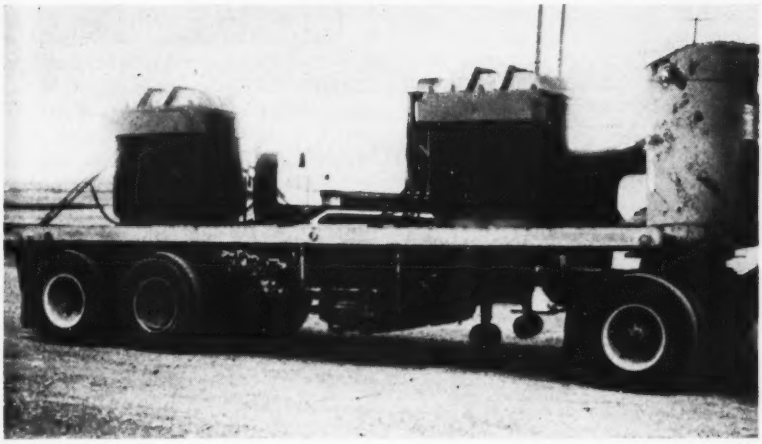
Where loading is done under water it is necessary to have a means of draining the water from the cask. Usually this is accomplished by means of a plug near the bottom which can be removed for draining. It is sometimes necessary to have a vent in the top of the cask, although the cover is usually not seated tightly enough to prevent air from entering.

These operations explain why containers often may be unreasonably subject to damage if proper attention is not given to the location of drains and other openings, and particularly to the design of the covers. Design should be such that even with a fairly severe jar or jolt, such as might occur in an accident, the radioactive substance will not be released from the container.

In all the shipments on the site or leaving the site, 17 have been involved in accidents. Only one was a major accident involving the shipping vehicle; and in only one instance was any contamination involved. This latter occurred when an empty cask fell off a truck on the site and contaminated a



The object on the freight car is a 13-ton cask for shipping spent fuel elements. It is water-filled with heat dispersion fins. Note the blocking and cables required to assure the safety of the equipment.



Two 13-ton containers for shipping spent fuel elements mounted on a truck. This particular shipment was going to stay within an AEC site during transportation, so it was secured by chains which would not be recommended for long haul off-site transportation.

roadway to the extent that cleanup was required.

Tying Casks to Vehicles

A near incident involved a truck that was bringing material to the National Reactor Testing Station. Loaded with two large containers, the truck skidded on an icy road. The trailer slid down an embankment, while the tractor itself remained on the road. Only one of the two containers broke loose, but both were damaged without breaking open. Fortunately, there was no radiation problem.

The foregoing illustrates why we require that all large containers be securely fastened so as to stay on the transporting vehicle in all but the most serious accidents. Of course, this detail is stressed more for long-haul vehicles going off the site than for shipments between plants on the site, where radiation is a familiar problem and there are accepted controls.

The aim is to tie or secure the container to the transporting vehicle so that there is little or no chance of its breaking loose due to acceleration, deceleration, speeding around turns, sudden stop, or due to physical damage which might occur in an accident.

For shipments within the reactor station site, we permit containers to be anchored to vehicles by means of chains, but this is not permitted for off-site shipment. For long-haul trucks, the container must be secured by cable or, if the container is a light one, by stainless steel straps. Rail shipments must be secured by cable, by blocking or special frames which are welded to the car.

Securing the container is a major problem with commercial truck shipments. Commercial carriers are not experienced, equipped or trained for carrying heavy, concentrated loads such as the casks containing radioactive material. Most commercial trucks pick up containers at the reactor station site and take them to a freight terminal about sixty miles away. Before a truck is released to leave the site, we can require that the container be reasonably secured. However, at the terminal there is no control. Judging from how we find incoming shipments, it is apparently not the practice to require tiedowns for containers on trucks or railway cars.

There have been two instances which illustrate this deficiency; each involved a different truck line whose trucks were chartered for long-haul shipments with which our station was sending an escort. In both cases the trucks arrived completely unequipped to secure the casks which were to be loaded. We obtained cables but found that there was no place where these cables could be properly tied on the truck. The truck company refused permission to cut the truck floor to get to the frame. Finally, homemade tie rings were built, and holes were drilled to cross members of the truck frame where they were bolted. One of these makeshift rings failed in transit, and it was necessary to stop and make repairs. On both of these trips the escorts reported trouble with drivers operating at excessive speeds and being unwilling to make enough stops for checks of the load and for rest for the escorting personnel.

Fires in Transit

Of course, the problem of fires in trucks in transit is not limited to the shipment of radioactive material. The main problem is that it is difficult to carry, on the truck, extinguishing equipment with adequate capacity to take care of every and all fire situations which may be encountered. Our usual recommended arrangements provide dry chemical extinguishers, a 4-pound extinguisher in the cab and a 30-pound extinguisher mounted outside between the cab and trailer. Another 30-pound extinguisher is usually carried in the escort vehicle. The escort vehicle also carries a 30-pound unit with one of the proprietary extinguishing agents useful in controlling metal fires. This is because pyrophoric metals may be among the materials in some shipments.

A fire in a truck which was bringing material over the road from a distant site to the station illustrates this problem. The shipment was covered with a canvas tarpaulin. In transit the tarpaulin caught fire (from an unknown source) and set fire to some wooden blocking. The driver noticed the fire in his mirror, stopped the truck and first attempted to put out the fire with a small carbon dioxide extinguisher. The unit proved to be inoperative. The driver also had a 30-pound unit for metal fires which gave him enough extinguishing material to deal with the fire at the stage in which he found it. This did not involve any radiation problem.

Escorted Shipments

Some shipments are escorted. This means that the material is accompanied at all times by personnel who can see that the shipment is not tampered with and is properly handled.

Escorts are also trained to take appropriate action in emergencies. The escorting personnel who are furnished by the Security Division are trained in problems of health physics, safety, first aid and the use of fire extinguishers. An escort vehicle will carry protective clothing, respirators, radiation survey meters, first-aid kits, the extinguishers which have been described, and a number of additional items of equipment, including rope, red flares, emergency lights, and radiation signs.

Where there is a shipment by long-haul truck, the escorts ride in a separate vehicle, the truck and escort vehicle maintaining contact by radio. Sleeping arrangements are provided both in the truck and the escort vehicle so that travel proceeds on a twenty-four hour basis.

In these long-haul shipments routes are carefully planned in advance, and every effort is made to avoid taking the shipments through heavily populated areas. The new turnpikes in the eastern part of the United States have greatly helped in this regard. Changes in route can be made, but in such cases the Idaho Operations Office security center is advised of such a change.

Fire Tests and Fire Protection Engineering

By A. J. Steiner

Managing Engineer, Fire Protection Department

Underwriters' Laboratories, Inc., Chicago

Classification of building materials and building structures according to fire protection criteria is one of the major problems confronting regulatory bodies. The problem involves the selection of proper classifications based on interpretations of test results relating to the burning and resistance-to-burning of materials and building assemblies in terms of exposure to fire under actual use conditions. In recent years, test results have created much uncertainty because identical classifications result from different tests and because many tests are actually designed only to show variations in performance without regard to their performance under actual use conditions. Fire protection engineers must decide which tests warrant recognition.

The Underwriters' Laboratories test for fabrics treated to make them flame resistant. Here a technician measures the flame spread and duration of burning, using an 11-inch Bunsen burner and a 5 inch wide by 7 foot long specimen.

The purpose of this article is to review some of the test methods developed by various groups for purposes *other* than fire protection, in the hope of correcting the misunderstandings which exist. The problem is increasing because more so-called fire test procedures are being developed and promulgated by groups primarily interested not in fire protection but in demonstrating the comparative behavior of materials.

Illustrations of the Problem

Flameproofed Fabric Tests

To illustrate, I would like to describe the test being used in the classification of flameproofed fabrics. It has been used for many years as the basis for acceptance of flame-retardant fabrics intended for tenting, tarpaulins, drapes, and curtains; and the test procedure has been promulgated in specifications issued by the U. S. Armed Forces, in other Federal Specifications, by the ASTM and others. It is particularly important because burning fabrics have been responsible for disastrous spread of fire. The test calls for specimens to be strips 2¾ inches wide by 10 inches long. These are exposed to a 1½-inch flame applied for 12 seconds. The length of char is then measured, and the time of

flame and glow observed. The test does compare the efficiency of flameproofing in fabrics *of the same kind*, but it does *not* adequately evaluate the flameproofing qualities of fabrics *of different kinds*. The results of such a small-scale test simply do not provide the information needed on how large tents, curtains, or drapes will respond to fire exposure.

For many years, Underwriters' Laboratories, Inc., has, in its classification of flameproofed and noncombustible fabrics, used a larger scale test. For fabrics in single sheets, the specimens used are 5 inches wide and 7 feet long; for fabrics hung in folds, the specimens used are 25 inches wide and 7 feet long, arranged as curtains in 5-inch folds. These are hung in the chamber where standardized air currents are created, and are exposed to an 11-inch flame for 2 minutes. This test, while it is also relatively small, at least has some semblance to field conditions.

NFPA has a Standard for Flameproofed Textiles (No. 701), dated 1951, in which both tests are included. This is a compromise influenced by the fact that for many years purchase specifications and regulatory bodies have generally recognized the smaller test requirements. The UL test will not be popular so long as the latter is accepted.

Fire Tests of Wall Assemblies

The following will illustrate another effort made by those desiring simple, small-scale tests. In the Standard Methods of Fire Tests of Building Construction and Materials (NFPA No. 251, ASTM E119–55, UL 263), the specimen is a representative section of a wall 100 square feet in area, with no dimension less than 9 feet. Using this test, the fire resistance of walls is established in time ratings of from 10 minutes to 4 hours or more; the rating indicates the duration such walls will provide fire protection. This test procedure was developed by a group primarily interested in fire protection, and after much deliberation, became a nationally recognized standard in the period 1910 to 1920.

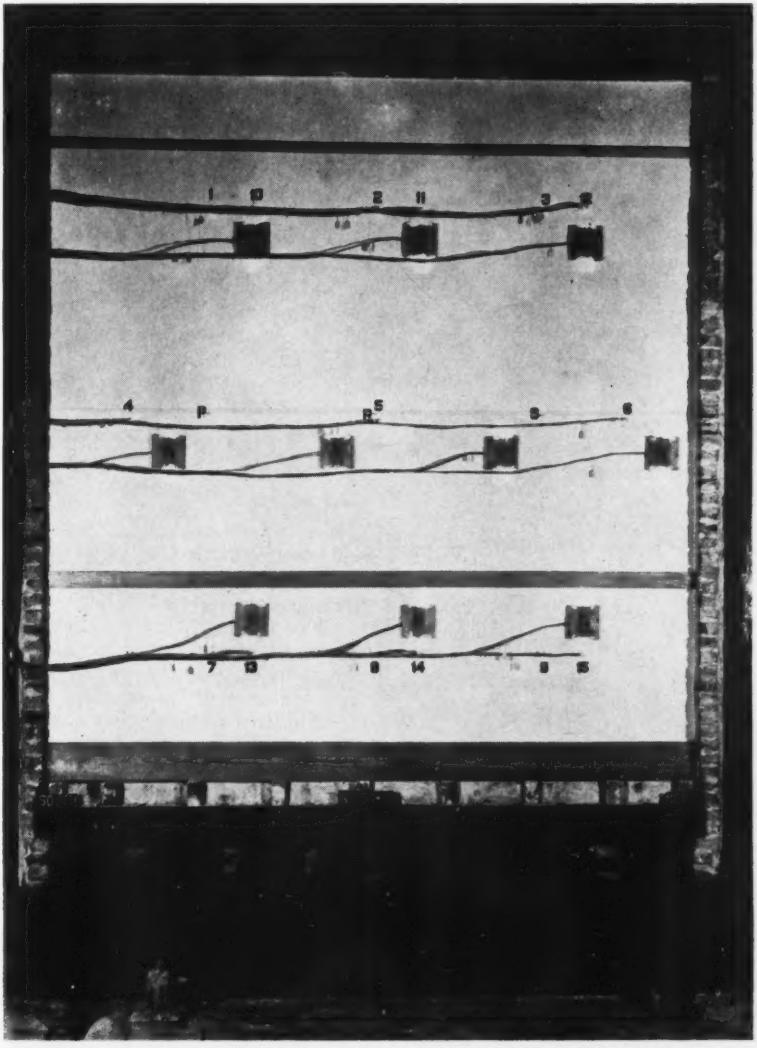
In recent years the test has been criticized because it is claimed that a wall section 10 feet by 10 feet is too large. This may be so if it is desired to study only the heat transmission properties of materials. However, if it is desired to study the behavior of a wall assembly *under fire exposure conditions*, a 10 by 10 foot sample is actually too small in comparison with the dimensions found in buildings. In these tests it is essential to study the movement of the structure as well as heat transmission under fire exposure. The stresses and strains developed by the heat, in most cases, have more effect on the performance of a wall under fire exposure than does the heat transmission of the materials used. Structures buckle and distort as a result of fire, and this also occurs, to a limited extent, in the standardized test of the 10 foot by 10 foot section of a wall.

A few years ago, the American Society of Testing Materials (ASTM) Committee E-6, interested primarily in structural behavior of walls under normal use conditions, desired to standardize on a fire test for walls using specimens 3 feet by 3 feet or 4 feet by 4 feet in area. The reason given was to provide a standardized procedure for development and research by materials manufacturers attempting to design walls for a particular fire resistance classification. This seemed to be an attempt to gain recognition for a small-scale test which would certainly provide a good tool for development and research, but which would not be appropriate for establishing fire resistance classifications of wall assemblies since structural behavior of walls under fire exposure could not be demonstrated with such small sections. Considerable effort was required by those primarily interested in fire protection to keep this small-scale test from becoming recognized as an official fire resistance test.

These are only two examples of the many in which fire tests are developed in the interests of comparison of materials rather than from the fire protection

viewpoint of behavior under actual fire conditions.

Industrial progress, including the establishment of research departments, is resulting in the creation of many new materials; these prompt the development of tests to show their desirable properties in comparison with the old materials they may replace. When a new material is created, a market for it must be found. Usually, specific use or



The large scale wall assembly fire test method as detailed by NFPA No. 251. The section is 100 square feet in area with no dimension less than 9 feet. This test panel is at Underwriters' Laboratories. Smaller scale tests are not adequate to simulate actual fire exposure conditions.

uses are developed on the basis of common, normal exposures without regard to fire exposure, until building officials and fire protection engineers raise the question. Some people who have developed a new product attempt to answer questions regarding fire hazard by small-scale tests which compare its behavior with that of the material it replaces rather than show behavior under actual fire conditions. Efforts are made to persuade us that fire test exposures used in the past are now too exacting.

Tunnel Test vs. Small-Scale Tests

One of the most controversial tests of the last twenty years is that developed by Underwriters' Laboratories for the purpose of testing surface burning characteristics of building materials. Commonly referred to as the Tunnel Test, or the Fire Hazard Classification, and adopted in 1955 as NFPA Standard No. 255, it is a large-scale test which was evolved because of the need for fireproofing coatings and the creation of new building materials.

Development of Tunnel Test

The exposed surface of lumber used in buildings can be a serious fire hazard, and from 1910 to 1920 various coatings were produced to reduce the hazard. The first tunnel furnace was developed at that time to determine the efficiency of the coatings.

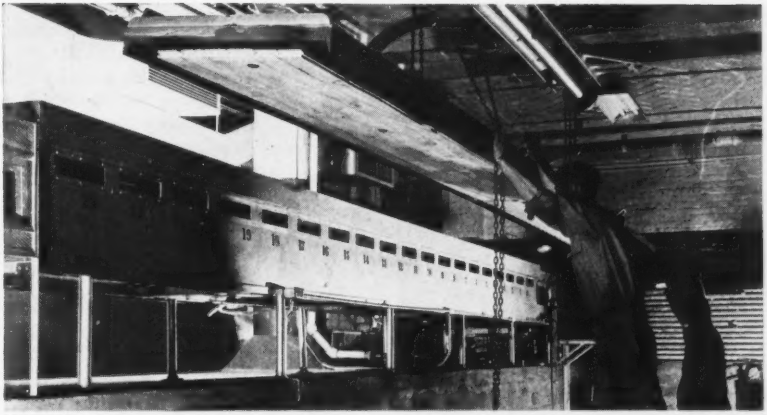
By the early 1920's, lumber was being treated with chemicals by the pressure impregnation process. About the same time, cellulose fiberboard arrived. These events increased the need for answers to the questions, "How will this burn?" and "How 'fireproof' are these?" This need was the prime motive for the development of a flamespread classification. In rapid succession, other materials appeared on the market, like coatings for steel surfaces, plywood, acoustical and decorative tiles, insulation materials, various adhesives for bonding combinations of materials, plastics, and other materials in various forms applied to building constructions in various ways.

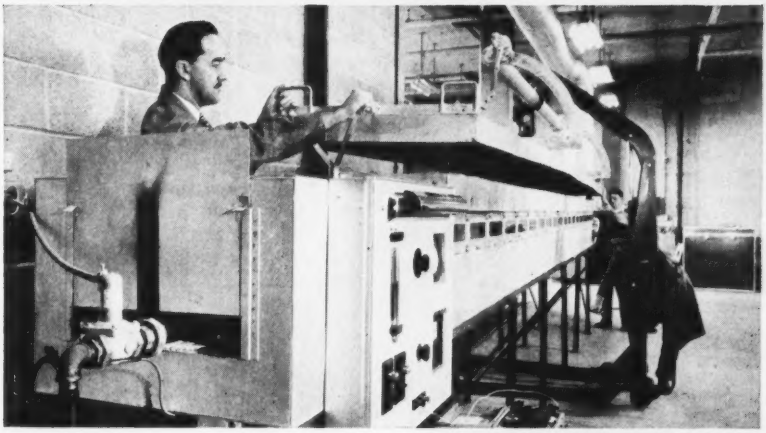
These developments again emphasized that comparative tests for materials do not provide fire protection information on how combinations of materials will actually respond in a fire, especially when they are applied to buildings by various methods. Field experience has repeatedly demonstrated that test specimens must be representative, and that they must be sufficiently large to provide realistic reactions under fire exposure conditions which are not directly visible under normal conditions but which contribute to flamespread, structural stability, and heat penetration.

The Tunnel Test provides a means for determining these factors. Nevertheless, because it is a large-scale test, there has been a reluctance on the part of many manufacturers to use it. Instead, small-scale tests like those described below have for years been presented to regulatory bodies to establish classifications of performance under fire conditions.

Small-Scale Tests

It must be recognized that small-scale tests are effective instruments for development and research, as well as tools for inspection. They run into trouble, however, when they are employed for measuring the fire resistance of a material. For example, small-scale tests are used to demonstrate the efficiency of treatments applied to combustible materials to reduce flamespread; in one such test the untreated end of a small paper-thin strip of material is ignited with a match-size flame which burns until the fire extinguishes itself when the treated portion is reached. This is a very effective demonstration to those not well informed on fire behavior. Surface applied treatments do not affect building products the same way they do a paper-thin strip of material in that they do not penetrate to a significant depth, but generally are on the surface only. The joints between sections and backs are not benefited at all by such treatments.





Shown are three large scale building material fire test tunnels of the scale recommended by Mr. Steiner to properly evaluate the behavior of structural components for application to broad fire protection engineering problems. At the top is the installation at the Underwriters' Laboratories in Chicago. Next is shown the tunnel test apparatus at the Underwriters' Laboratories of Canada and at the bottom right similar test apparatus at the Southwest Research Institute, San Antonio, Texas. NFPA Standard No. 255 calls for the use of this type of apparatus, commonly referred to as the "Tunnel Test," for testing the surface burning characteristics of building materials.

This is a modified Schlyter apparatus as used at the Forest Products Laboratory in the U. S. It was developed originally by the State Testing Laboratory in Sweden in 1935. It is used to evaluate the effectiveness of fire retarding coatings on combustible surfaces.

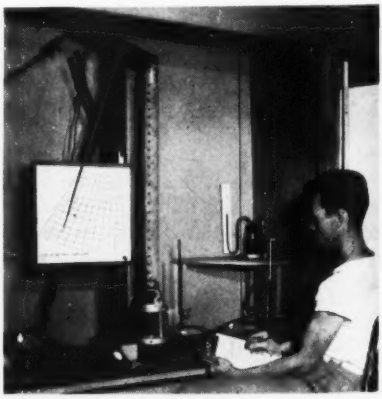
Dog-house Test

A demonstration in which two little dog houses were exposed to fire makes the difference clear. One dog house was treated with a so-called fireproofing coating or paint, while the other was not. A flammable liquid was applied to both houses, and the vapors ignited. At the end of the demonstration, the uncoated house was burned to the ground, but the coated house, even though liquid had been repeatedly added, remained standing. This was a fantastic demonstration of the efficiency of the coating if one ignores basic facts of fire protection engineering. It showed that the flammable liquid burned on the surface of the coating but that the liquid applied to the uncoated wood soaked into the fibers and burned like a wick. In the areas where the ignition occurred, the flame grew and eventually consumed all the wood. The demonstration did not show how such a coating material would prevent the spread of fire in an actual building where all surfaces are not coated, where joints open readily due to movement of material, or where combustible materials are held with adhesives that loosen from heat. The smaller the size of the sample, the less physical reaction is produced that simulates those occurring under actual fire exposure conditions.

Other small-scale tests have been introduced for fireproofing coatings. One of these is the Schlyter test, in which a flame is placed for three minutes in a 2-inch space between two 12 by 31 inch parallel surfaces. The spread on the surfaces after the exposing flame is removed is recorded to show the effectiveness of the coating. A number of other tests providing similar observations have been developed for paint coatings.

Treated Wood Tests

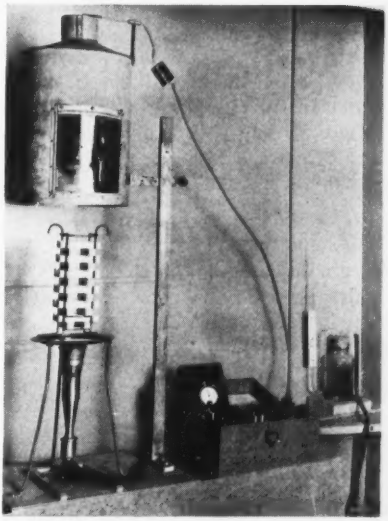
A number of small-scale tests are being used to demonstrate that pressure impregnated lumber provides fire protection. One of them is the Fire Tube Test for Treated Wood developed in the 1920's by the Forest Products Laboratories. A specimen 40 inches long and ⅜ by ¾ inches in cross section is suspended in a metal tube. The bot-



Devised about 1928 at the Forest Products Laboratory, the fire tube test was designed to furnish information on pressure impregnated fire retardant lumber. Due to the small scale nature of the test, the NFPA has withdrawn its recognition of this method for broad fire protection engineering application.

tom end of the specimen is exposed for 4 minutes to an 11-inch Bunsen burner flame placed 1 inch below the specimen. The duration of the flame after the burner is removed is recorded, as are also the duration of the glow after the flame ceases and the weight loss. This test became an ASTM Standard (E69) in the late 1940's and an NFPA Standard in 1950 (NFPA No. 253). While the test provides a tool to check the efficiency of the treatment introduced in that specimen, the specimen is not representative of lumber of greater cross section, and therefore, does not provide information on how a door, partition, column or beam made of lumber similarly treated will perform when exposed to an actual fire. Because it was realized that this test was an inspection tool and not an aid in fire protection, it was withdrawn by the NFPA Committee on Fire Tests in 1958.

Similarly, crib tests of two kinds have been promulgated for pressure impregnated lumber. The first was developed in the early 1920's by New York City, with the cooperation of Columbia University, for use in connection with New York's City Building Code operations on pressure impregnated lumber. In this, the sample consists of 12 pieces, each 6 inches long by ½ inch square in cross section, laid in the form of a crib of three layers and exposed to a Bunsen burner flame of 1200°F for one minute. Later the procedure was modified to 24 pieces, 3 inches long by ½ inch square in cross section, laid in the form of a crib 12 tiers high, two pieces in each layer, and exposed to a 10-inch Meker burner flame for 3 minutes. In both these crib tests the duration of the flame after the burner is removed was noted, as well as the duration of the glow after flaming ceased, and the loss of weight. The latter test was developed through the efforts of an ASTM Committee and became an ASTM Standard (E160) in the late 1940's, and an NFPA Standard (No. 254), in 1950. However, for the same reasons as the fire tube test, it was withdrawn in 1958 by the NFPA Committee.



A small scale test used to determine the effectiveness of flameproofing treatments of wood known as the "crib test." NFPA has withdrawn this test method as being unacceptable for broad fire protection engineering application.

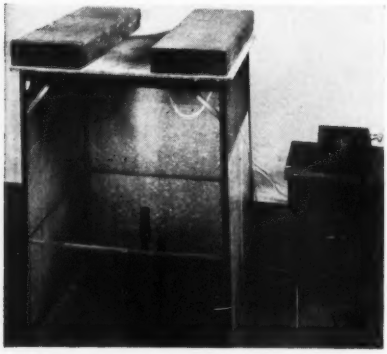
While these tests have value for determining whether the chemicals used to treat the wood meet purchase specifications, it has been repeatedly shown that no realistic fire protection classification for building members could be established by them. Nevertheless, railroads, building codes, and even NFPA have recognized these as fire protection tests for regulation purposes. It is rewarding, at least, that in 1958 the NFPA withdrew its recognition.

Other small-scale tests for treated lumber were adopted by the New York City building code during the 1930's and 40's, including a shavings test and a timber test.

Acoustical Tile Test

In the 1930's, acoustical tiles were first marketed. Because fire experience indicated that some of them burned rapidly, and because no test for their flamespread was available, government

agencies requested some method whereby the highly combustible tiles could be identified. The Federal Specification Board came up with Test SS-A-118 which was later revised and is now SS-A-118b, entitled Acoustical Units; Prefabricated. This test, developed by Columbia University, was used by the Bureau of Standards for the purpose of developing the Federal Specifications, and terms such as "slow-burning" and "fire-retardant" were introduced originally for classifications of acoustical tile, in addition to the terms "combustible" and "noncombustible."

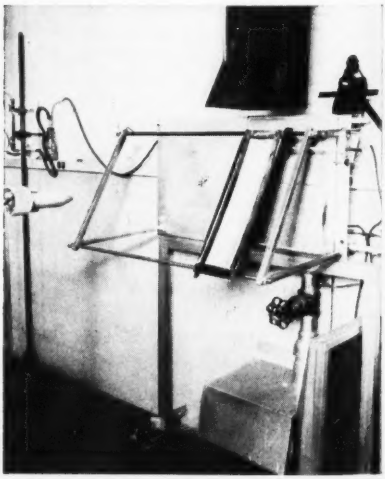


U. S. Federal Spec. SS-A-118b. covers prefabricated acoustical units and the illustration shows the method specified for classifying the combustibility of samples. Most fire protection authorities prefer larger scale tests to evaluate flame spread, fuel contributed and smoke developed by these assemblies.

In the original test, the sample was a panel 3 feet by 3 feet, mounted on an angle frame in a horizontal position; flame was applied vertically against the underface. Depending upon the diameter of the area to which the flame spreads, the tiles were classified as noncombustible, fire retardant, slow-burning, or, if the flame reached the angles, combustible. Under the term "combustible," tiles which continued to spread fire could not be distinguished from materials which did not spread fire. After this test had been used for some time as an aid to government agencies to select acoustical tile on a flame reaction basis, it was enthusiastically received by producers of highly combustible materials intended for varied uses, who employed it to classify materials according to their burning characteristics. Today, the same producers are making attempts to classify other new materials by the same method in ASTM Committees on Insulation and Acoustical Materials, and have been successful in having it adopted in some building codes. Although the test has been revised a number of times, it still does not provide a basis for classifying materials according to spread of fire under actual use conditions. Here is a test which was originally adopted as an inspection tool but is now being promoted to classify some of the many building materials which burn rapidly.

NBS Radiant Panel Test

These same forces have attempted, and are attempting, to make use of



The National Bureau of Standards in Washington uses this radiant panel flame apparatus as a method of classifying the fire hazard properties of combustible building products. While some of the results achieved from this test agree with the larger tunnel tests, the small scale nature of the test is seen as a limitation by Mr. Steiner.

other small-scale tests; for example, the Bureau of Standards has recently given publicity to a method referred to as the Radiant Panel Test, which was adapted from a test developed by the British Department of Scientific and Industrial Research and the Fire Offices Committee. In this test a 6 by 18 inch specimen is faced toward a radiant panel at an incline of 30 degrees, and the progress of flame across the surface is observed. The test is undoubtedly a convenient instrument for the study of the ease of ignition and the rate of flamespread on the surface of the material, but the sample is too small to cause the distortion of surface or joints which occurs when building surfaces are exposed to fire.

The Bureau of Standards has shown that, in general, the results on certain materials tested by the Radiant Panel Test match the results in the Tunnel Test, but the action which develops stresses and strains under actual fire conditions is not reproduced. The promoters of this test always state that it can be conducted cheaply and quickly. That is true, but it does not provide the information needed to solve fire protection problems. From a realistic standpoint, a surface 6 by 18 inches cannot contain the variations representative of those produced by the surfaces actually existing in buildings.

Forest Products Lab Small-Scale Test

Some years ago, the Forest Products Laboratories in Madison, Wisconsin, accepted an assignment from ASTM Committee E-5 to develop a test which would simplify and use smaller samples than that in the Tunnel Test. After a number of years, the Forest Products Laboratories evolved a test in which a sample 13¾ inches wide, 8 feet long is tilted 30 degrees from the horizontal. The specimen is ignited by temperatures from a hot partition over the firebox, and by combustion gases coming through holes in the partition. This test, too, does not represent actual fire conditions.

Small-Scale Fiberboard Tests

Some of the small-scale tests described previously are large in comparison with a test that appeared some years ago (1932) in the British Standard Definitions for Fire Resistance, Incombustibility, and Non-Inflammability of Building Materials and Structures. The Non-Inflammability Test for board and sheet materials was adopted in this country as recently as 1955 both in a Federal Specifications and in a Commercial Standard (CS 42) for vegetable fiberboard and plywood. In this test the specimen is exposed to flames from alcohol in a ⅝-inch diameter, 9/32-inch-deep container, applied 1 inch from the underside. This test was presented at one of the meetings of the NFPA Committee on Safety to Life a few years ago, when an attempt was made to obtain recognition of fire exposure equivalent to the severity of a thimbleful of alcohol.

This may seem absurd, but persons in regulatory positions are confronted with such tests recognized by ASTM, Federal Specifications, Commercial Standards and other government agencies and the armed forces.

Plastics a Current Problem

Today the promoters of plastics for use in building construction confront us with terms like "slow-burning" and "self-extinguishing" deduced from ½ to 1 inch wide strips of sample plastics, exposed to flames for from 15 to 30 seconds. These terms were used in the ASTM Specifications D568 and D635 prepared by Committee D-20 on Plastics for comparative purposes back 10 to 15 years ago, long before plastics were ever considered as building materials. In recent years the committee has changed the scope of these specifications to definitely state that the tests are not intended for building code regulations. Nevertheless, the plastics industry is promulgating these tests for building code classification on the basis of such terms as "slow-burning" and "self-extinguishing."

This test equipment for conducting comparative burning tests of common plastics is totally inadequate for testing the behavior of such materials when used as building materials.

In the current (1956) tentative ASTM Test D568, a strip of plastic 18 inches by 1 inch is exposed to a 1 inch flame from a Bunsen burner for 15 seconds. In the current (1956) tentative ASTM Test D635, a strip 5 inches by ½ inch, held horizontally, is exposed to approximately a 1 inch flame for 30 seconds. If the flame does not travel 4 inches after the first or second 30-second application, it is referred to as "self-extinguishing."

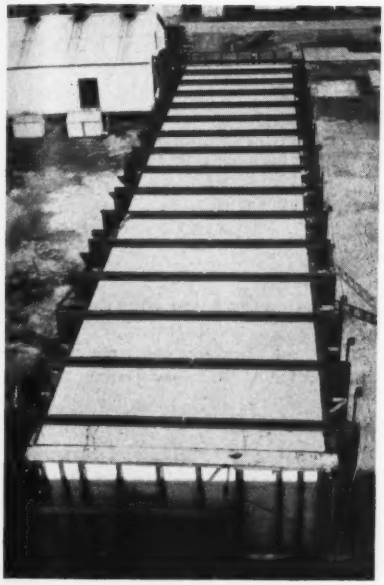
Plastic sheets are now used to replace corrugated sheet metal in steel buildings, as noncombustible windows and skylights and for interior surfaces. It is not sufficient, from a fire protection viewpoint, to accept classifications such as self-extinguishing and slow-burning based on such tests. The acceptance of any material must be based on conditions of exposure which can be anticipated under actual fire conditions. Nevertheless, some building codes have included a chapter which classifies plastics by these tests.

Other Test Considerations

We have had some unfortunate instances in which acceptance of materials and devices is based on test results which have no significance in the classification of their uses. Is it not consistent to expect that where fire protection problems are present, a new material or assembly shall be as fire resistive as the materials or assemblies it replaces, unless experience indicates that the existing requirements are not necessary? Is it not proper to expect that test results should be based on performance under actual use conditions?

The results of the Radiant Panel, Small Tunnel, and some other small-scale tests have been quoted as being as reliable as those obtained in the Tunnel Test. Underwriters' Laboratories, Inc., has now been using the Tunnel Test for testing and classifying for over 15 years, but it cannot be passed as a Standard in ASTM because of much petty bickering by the same people who are so successful in replacing the efforts of fire protection engineers. However, the NFPA has made the Tunnel Test a Standard, and other fire protection organizations, like NBFU, use the criteria of the test in a number of their publications.

Those inexperienced in fire protection want smaller samples, but those who have devoted their lives to fire protection insist upon larger ones. A good ex-



The Factory Mutual Laboratories use this large scale test facility to evaluate roof deck assemblies as to their fire hazard characteristics. The structure is 100 ft. long, 20 ft. wide and 10 ft. high. For full details see October 1955 Quarterly, page 92.

ample is the tunnel 20 feet wide and 100 feet long used by the Factory Mutual Laboratories to reproduce conditions of the holocaust at Livonia, Michigan, several years ago. The small-scale tests can be used in the examination of products to determine whether they provide the same properties as other materials tested in the same manner and for development and research, but they do not provide fire protection information on the behavior of the product, or of assemblies employing it, under actual use conditions in buildings.

General Test Criteria

It may be well to point out that the same fire protection engineering considerations must be given to all tests, whether small or large. The results must be representative of actual conditions, the classifications must be realistic and the requirements consistent. The following are just a few examples of improper tests from fire protection engineering consideration.

A building code has given recognition to passenger elevator doors based on a fire test conducted on a door assembly fastened rigidly by bolts to the masonry opening. Such a test does not provide realistic indications of how the opening is protected when the door is mounted with the usual hardware.

A large insurance group has based its classification of certain plastics as noncombustible on a test of roof structure in which the exposing fire developed a hole through which the flame and heat escaped. How will this product react when the fire is applied to the lower edge of a vertical installation, or to an installation where the hole will not provide the favorable conditions they created?

Some building codes and inspection organizations accept fire windows based on general construction specifications of the frame without standard fire tests. When a fire occurs, will the frame hold the glass in place to prevent flame passage?

A three-hour fire door is one which will under standard fire test exposure remain in position for three hours. Regulations for installation recorded in NFPA No. 80, prepared by fire protection personnel, state that a door shall be hung on each face of a fire wall to provide the desired protection of a fire wall. Some building codes permit 1½-hour doors to be used on one face of the wall. Are such variations based on fire protection engineering or test specifications?

Fire test results obtained by analog computers will soon be issued. It is not proper for me to express an opinion on the reliability of such computations. However, it is proper to point out that the answers produced by these machines are dependent upon the information fed

into them. Fire protection engineering knowledge is necessary both for determining the data to be used, and for proper analysis of the results.

Structurally, the design of laminated wood trusses, various beams of reinforced and prestressed concrete, columns and floor designs, have been developed on the basis of research and experimentation by small-scale tests, but final acceptance is based on engineering calculations and large scale tests. Some such structures fail under fire exposure because fire protection engineering was omitted and tests on a large or realistic basis were neglected.

Summary

It is the responsibility of the fire protection engineer to oppose the activity of groups not properly qualified to promulgate tests and classifications on fire protection problems. He should not be misled by results obtained in fire tests which have no relation to actual fire conditions. When the results of a test are presented, the fire protection engineer must be certain that the materials to be used on the job are the same as those tested, and that they are installed as tested. This follows the accepted practice of the engineering profession, whether building for safety against collapse or for safety against fire.

A U. S. Program of Fire Research

By Howard W. Emmons

Professor, Division of Engineering and Applied Physics

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The problems associated with the accidental fire and its extinguishment have been with us from the dawn of history. Man's continuously growing knowledge of materials and physical processes has made possible a parallel growth of both the means of fire extinguishment and in modes of construction for fire prevention. However, the large conflagration, either city or forest, releases uncontrolled energies so great that man has been nearly helpless.

While peacetime conflagrations in cities in the more highly developed countries are very unlikely today, the widespread wartime use of incendiary bombs and, more especially, use of atomic bombs makes consideration of the city conflagration problem urgent. Even without the wartime fire problem, the protection of our forest resources would greatly benefit from improved methods of extinguishment. (Known methods of prevention and control could greatly reduce the large forest fire hazard, but are uneconomical by several orders of magnitude.)

The National Academy of Sciences — National Research Council with Federal Civil Defense Administration (FCDA) sponsorship set up a Committee on Fire Research and the Fire Research Conference in 1956. The study of the fire problem included a study of work now in progress by the various government agencies, private agencies and university research laboratories, both in this country and abroad. The magnitude of the work in progress is impressive indeed. However, it became clear to the Committee by late 1957 that in spite of all the work already in progress there was one area in which additional work seemed desirable. This area, for want of a better name, is "the science of fire."

Although the sciences have been studied for many centuries, only within this century have they contributed in a major way to the everyday life of the average citizen. Of course, these developments have not been neglected by those now engaged in fire research. However, the methods of science, of extensive quantitative study of all the minor details of a phenomenon in the light of the mathematically exact knowledge of physical laws, is necessarily a slow one. Moreover, history shows that very rarely can such study guarantee a solution to a prestated problem. The really important contributions from such a study generally have emerged from the unexpected importance of some initially obscure minor detail; the discovery of a quantitative relation initially unsuspected. If men in the past few centuries had not carried out such basic studies in many fields we would not today have radio, penicillin, nuclear power stations, or innumerable other essential devices.

A fire burning in an uncontrolled way through the combustible material of a city or forest is exceedingly complex. Until the present day a study of the

Based on a talk presented by the author at the 1958 NFPA Fall Conference held in Pittsburgh, Pa., Nov. 17–19. Professor Emmons distributed to those present at the Conference the first issue of a new periodical entitled "Fire Research Abstracts and Reviews" published under the auspices of the Committee on Fire Research and the Fire Research Conference of the United States National Academy of Sciences — National Research Council, 2101 Constitution Avenue, Washington 25, D. C. Members who would be interested in receiving a sample copy may request one from the National Academy at the address given.

basic quantitative nature of fire would have been virtually impossible because of the inadequacy of man's knowledge of the chemistry of combustion, the motion of air and hot gases, the transfer of heat by radiation (to name but a few). Now, however, knowledge is sufficient to warrant basic fire research.

It must be realized that, like all really basic studies, specific practical results cannot be promised by specific dates. If the proposed program is supported by Federal or other funds, we must not expect a new fire fighting device by next year bearing the label of "Developed under the National Fire Research Program."

The Proposed Fire Research

Actually, the program which I describe is still in the proposal stage and no major effort is as yet under way.

The proposed fire study must contain three closely coupled parts; laboratory studies, field studies and theoretical studies, of which the last must be an inherent part of both of the other two. When a phenomenon is understood, a majority of tests can be most easily performed on a model scale. Also, when a quantitative understanding is desired, the majority of tests can and should be made on a model scale. As a consequence, the proposed program recommends studies of all aspects of model fires, the air movements, the radiation effects, the fuel distribution effects, the effects of moisture in the fuel, the effects of extinguishment agents and others.

Careful quantitative test results on fire will require more detailed quantitative studies on the nature of fuels, their heating, their ignition, their mode of decomposing and charring, their mode of collapse. Thus, more work on these aspects of burning fuels needs support.

As with all complex problems, the scale of investigation must include the sizes of direct concern. The fire problem is no exception. Highly instrumented and extensively analyzed burns, from piles of packing cases and abandoned buildings to experimental forest areas must be carried out in close collaboration with the laboratory workers. Even this is not a wholly adequate scale, but so far no one has found the "abandoned city" which could be burned on demand. On the mass fire scale then, our only peacetime source of information is the all too frequent large accidental forest fire. Extensive and careful quantitative measurements of every measurable effect are needed to check, guide and supplement the laboratory tests. Wind, atmospheric and fuel moisture, topography, fuel distribution both vertical (grass, brush, trees) and horizontal (open areas and dense growth), meteorological factors, exact nature of control operations and their quantitative effects must be measured and quantitatively analyzed. To get this information will require extensive and difficult collaboration between the branch of the forest service attempting to get control of the fire and the laboratory group getting the measurements. Clearly there must be no interference with the work of fire extinguishment. Thus much of the collaboration must consist of the development of many unique measuring instruments that can take measurements without any interference (such as by radio transmitting measuring instruments — perhaps air dropped, which could be abandoned, but which could, before being consumed, telemeter the desired data).

While no new program is yet in progress, extensive interest in the proposed fire studies has been shown by the National Forest Service, the Defense Department, and the National Science Foundation. At present, the National Academy Fire Research Committee work is being sponsored jointly by the FCDA, the U. S. Forest Service and the U. S. Department of Defense. The Forest Service is considering the enlargement of its research laboratories in which some parts of the proposed program could be carried out. The National Science Foundation has shown a willingness to support

research on some of the really fundamental studies of the physical and chemical phenomena found in fires.

Results Anticipated

I look forward to the day a few years hence when papers reporting the results of research on fire appear at scientific meetings. I also look a few years further off to another NFPA meeting at which results of direct interest to this audience may be presented; and again, a few years more, to the time when some of the basic understanding will have progressed to the point that at least in some small way it may contribute some useful fire fighting ideas and equipment improvements which will make it possible for the firemen of the world to do a still better job in their most difficult task of protecting society from the ever present danger — a fire loss.

OUTLINE OF PROPOSED FIRE RESEARCH PROGRAM

Reprinted from Fire Research Abstracts and Reviews, Vol. I, No. 1.

In this outline that portion of the program directed toward understanding the physics and chemistry of fire and fire spread has been divided into two categories, *Laboratory Studies* and *Field Studies*. Each of these must be accompanied by theoretical studies to give guidance and meaning to the experimental work. The third section covers *Operations Research* and the fourth section deals with *Ad Hoc Developments*.

I. Laboratory Studies

A. Ignition and Combustion Properties of Fuels

1. Gas evolution from heated solids — rate as affected by mode and rate of heat application. Flammability limits of evolved gases

2. Effect of fuel geometry on ignition and early stage combustion characteristics of fuels

3. Rating of various fuel types, solid or liquid, by ignition temperature, heating cycle to produce ignition, energy absorption to ignition

4. Effects of fuel- and air-moisture

5. Heat and material transport and reaction phenomena inside the surface of heated combustibles

6. Convection *vs.* radiation as an ignition means

7. Gas-phase reaction kinetics in relation to flame suppression

B. Model Studies for Quantitative Prediction of Convection

1. Using flameless heat source

a–e. Effects of wind, topography, lapse rate, energy liberation rate and its distribution in space

2. Using fire as the heat source

a–e. Study of effects under B1 above

f. Convection pattern in and near the fire

C. Model Studies of the Factors Determining Radiation

1. Effect of fuel type, condition, and geometry on total emission rate and its spatial distribution

2. Evaluation of view-factors (factors permitting estimation of radiation received by surfaces) of gaseous emitters as seen by fuel in various orientations, and of surface-to-surface view-factors

D. Determination of the Model Laws for Fire Development and Spread

1. Measurements to be made include such items as

a. Fuel-system properties and air properties (including temperature, wind velocity, humidity, lapse rate)

b. Total rate of energy release *vs.* time

c. Space-distribution of energy release rate

d. Temperature, convection and radiation pattern around fire

2. Problems to be studied

a. Mechanism of fire development and fire-front propagation

(1) Interaction of fuel properties, fuel-bed geometry, convection, and radiation

(2) Propagation by firebrands
a. Classification of firebrand types from urban and forest fires (by heating value, burning rate, contact area, etc.)
b. Flight characteristics of firebrands in relation to natural and convection winds
b. Delineation of range of importance of various model groups (identification of the many factors of micro- and macro-environment and their expression in quantitative form)
c. Testing of scaling laws by comparison of model and field results

E. Development of Quantitative Fire-fighting Relationships

1. The use of water on reproducible fires
a. Effects of rate, distribution, degree of dispersion
b. Determination of minimum water requirements for control under model conditions
c. Consideration of possible need for modifying water properties, especially surface tension, for model use

2. The modification of water as a fire-fighting agent

3. The use of other extinguishing agents

4. Fuel geometry changes to stop fire — before and during involvement

5. Modeling backfires — assessment of merits of different backfiring techniques

6. Testing of effectiveness of miscellaneous procedures

F. Developmental Program on Instruments for Laboratory and Field Use

(See, e.g., II A2)

II. Field Studies

A. On Naturally Occurring Fires

1. Types
a. Forest fires
b. Building fires
c. Other — lumber, oil, storage, etc.

2. Measurements on forest fires
a. Rate of area involvement
(1) By advancing flame front. Such measurements as
a. Expendable radio broadcasters placed in depth along fire front, with tape-recording reception
b. Ground photo studies of local effects
c. Time-lapse photography from the air
(2) By spotting. Measurements generally by reliance on visual or photographic evidence, plus some data from instruments used in A2a) (1) (a)
b. Vertical involvement. Rate of area involvement at various elevations. Measurements as under A2a), at
(1) Ground
(2) Surface
(3) Crown
c. Fuel amounts and conditions in the fire area
(1) Before fire
a. Qualitative identifying description
b. Distribution curve of surface per unit mass *vs.* cumulative fractional mass
c. Variation of above distribution with height above mineral soil
d. Moisture content
(2) After fire — appropriate portions of above
(3) Rate of conversion from (1) to (2) at different times, for different fuel components. Rate obtained by timing each at selected intervals by actual on-ground observations
d. Ambient atmosphere at all significant elevations
(1) Wind speed and direction
(2) Turbulence
(3) Vertical motion
(4) Temperature
a. Lapse rate
b. Dew point temperatures
(5) Air moisture
(6) Cloud activity
e. Topography of fire area, obtained from maps
f. Fire convection column
(1) Measurements to be made
a. Speed
b. Height
c. Direction
d. Turbulence
e. Shape of column
f. Indraft pattern
g. Other phenomena — whirlwind, explosion, flash-over, etc.
(2) Possible methods of measurement
a. Time-lapse photography from fixed points on ground several miles from fire
b. Time-lapse photography from aircraft
c. Use of artificial vertical smoke trails to mark indraft and other air movement
(Measurements of these convection properties possibly by time-lapse photography, supplemented by close-up visual and photographic on-ground observations. Time-lapse motion picture photography provides an excellent continuous record of convection column behavior. Provision should be made for keying the film to a time scale. Film should be exposed from one or more fixed points several miles from the fire, and cameras should be capable of wide angle to telephoto operation. Pocket-size wire recorders are available for use in recording running account.)
g. Micro-weather around fire perimeter
(1) Air and fuel temperatures
(2) Surface air speed and direction

(3) Radiation intensity along fire front (4π pickup)

(All these measurements would profit by development of expendable transmitters)

h. Control status

(1) Portions of fire perimeter limited by control lines

(2) Backfires

(3) Water or chemical applications

(Control operations will be progressing during the period of investigation in most instances Continuous record of control work influencing the observed fire behavior is necessary in order to evaluate properly the observations. The fire control organization can provide some of the information currently, but must be supplemented by on-ground observations.

3. Measurements on other fires — generally parallel to those on forest fires, with some obvious modifications

4. Objectives

a. Formulation of conclusions which can affect present fire-fighting practice, equipment, and preventive measures.

b. Providing of an adequate quantitative description for use in planning model experiments. Determination of range of model-law parameters

c. Use of results for comparison with prediction from a simplified mathematical model; and determination of numerical values of coefficients appearing in the model

B. On Planned Fires

1. Types

a. Crib fires

b. Area fires using naturally occurring fuels — forest, brush, cane, grass, etc.

c. Area fires using multiple fabricated fuel units — packing cases, cribs, pans of oil, gas jets, etc.

d. Structure fires — including available abandoned buildings

2. Measurements (in general, similar to A2 with possibility of more adequate instrumentation)

3. Objectives

a. Formulation of conclusions which can affect present fire-fighting practice, equipment, and preventive measures

b. Providing of an adequate quantitative description for use in planning model experiments. Determination of range of model-law parameters

c. Use of results for comparison with prediction from a simplified mathematical model and determination of numerical values of coefficients appearing in the model

d. Testing validity of developed model laws based on laboratory studies, including the modeling of fire fighting

e. Inclusion of factors difficult or impossible to simulate properly on a laboratory scale, such as lapse rate and radiation

III. Operations Research

A. Operations Analysis. Rational planning of a fire control system requires recognition of and action on the following generalizations:

1. A fire control system should be planned to meet a clearly formulated protection objective

2. Preventing fires and putting out fires are the functions of fire control and should be balanced for maximum benefits

3. Putting out fires requires facilities and activities

4. The principal activities include measures undertaken before fires to make them manageable, to find out where and when fire does occur, and to put into effect measures to extinguish or limit the spread of fire

Each of these and its sub-parts presents a host of problems concerned with the selection of alternatives the best choice of which depends on decisions best made by application of operations analysis. Examples of these problems follow.

5. Urban fire control problems

a. Evaluation of a municipal fire control system through construction, on a computer, of the simulation of a fire and its response to the measures put into operation to deal with it

b. Optimum distribution of funds and effort between prevention measures and preparedness for fire fighting for a variety of conditions. Prevention studies would include, for example, an examination to determine the optimum interval between fire-prevention inspection of buildings; preparedness studies would include placement of fire companies, effect of running distance for fire companies, and traffic conditions on the amount of destruction which occurs before fire-fighting measures can be effective

6. Forest fire control problems

a. The evaluation of a forest fire control system through the simulation on a computer of a forest fire — its growth, the attack, and the decay of the fire

b. Evaluation and merits of different tactics including manpower distribution, equipment available, use of backfiring, evaluation of limits

c. Optimum fire crew spacing

d. Value of proposed new access roads (probably keyed to progress under a) above)

e. Optimum standards and frequency of firebreaks

f. Optimum distribution of funds and effort between prevention measures and preparedness for fire fighting, for a variety of conditions

7. Systematizing of fire reporting — the need for a common basis of reporting by fire departments in different cities. Possible desirability of central collecting agency

B. Experimental Field Research on Operations

Comparative studies of relative effectiveness of different fire-fighting techniques, strategies, tactics, and equipment

IV. Ad Hoc Developments

The existence and importance of a large amount of effort on fire control of a character dependent to a very minor degree on an understanding of the fundamentals of fire growth is recognized. Because the deficiency of effort here is so markedly less than in those fields more dependent on the scientific approach, this category will not be elaborated here. It is realized, however, that ideas may sometimes be presented which hold sufficient promise of quick development without research on fundamentals as to justify support of direct developmental effort.

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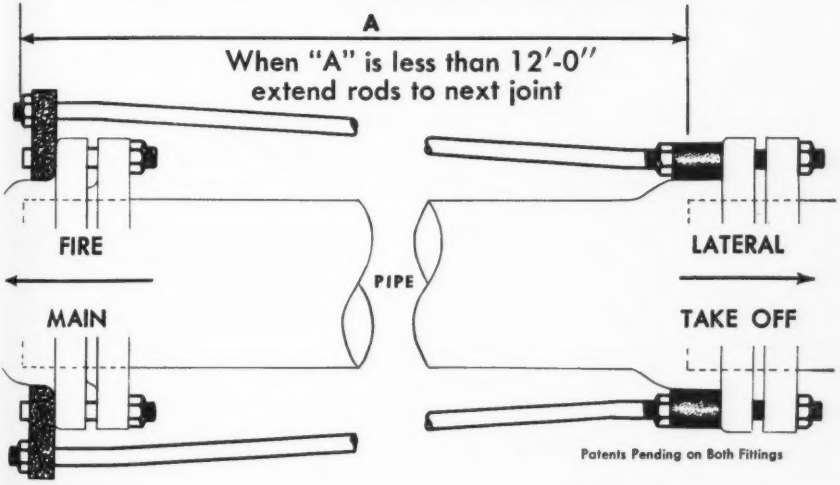

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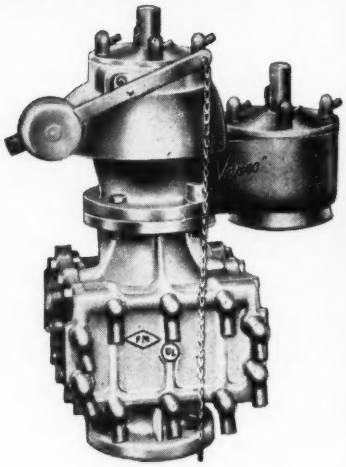

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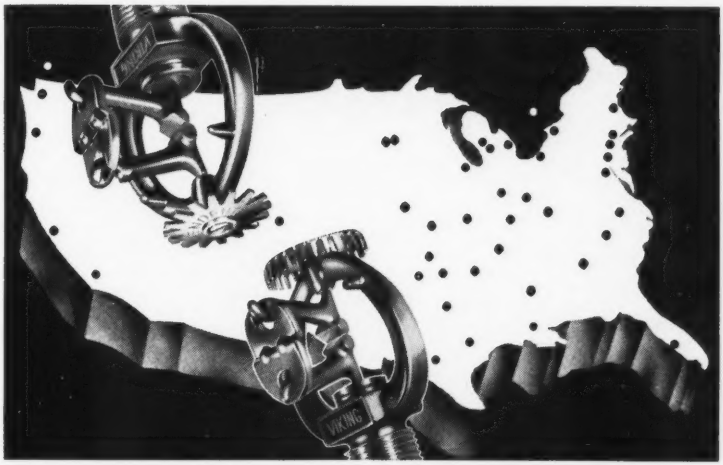

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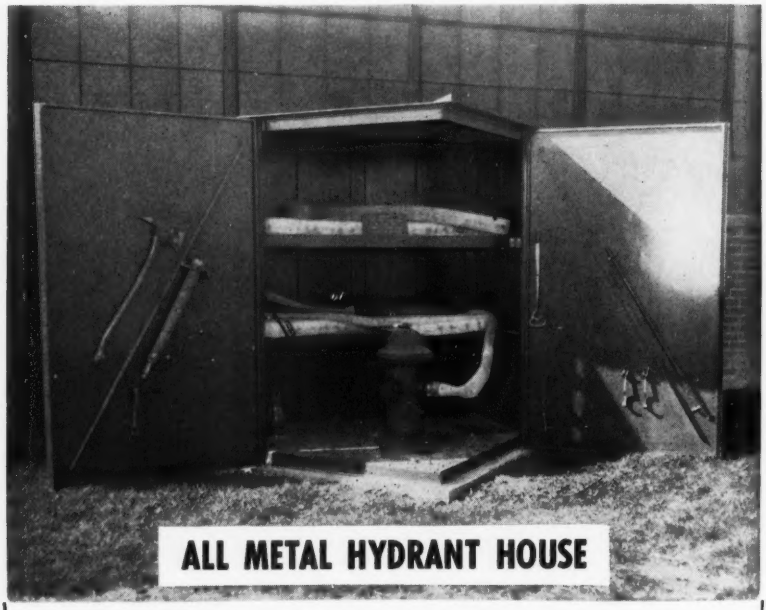
the VIKING corporation

HASTINGS, MICHIGAN



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Many Architects and Engineers are specifying the Model 60 or 60-L ALL-METAL Hydrant House on new jobs and recommend their use for replacement of existing wooden houses as they wear out.

The advantage of a Hydrant House is that it protects the hose and hydrant during inclement weather when sleet or snow cause heavy icing. The hose is coupled and ready at any hour of the day or night. All metal houses are weathertight and rat proof — will not warp or dry out. Eight (8) Louvers are stamped in side panels and shelves are perforated for ventilation. Finished weight — 600 lbs.

Houses are shipped from stock, knocked down. Roof, base, shelves, doors and panels are completely prefabricated of **galvanized iron with zinc plated hardware. Hinges are brass pinned.** All bolts for assembly are furnished. No cutting, drilling or welding is required in the field, thereby reducing the installation time to a minimum. Instructions are furnished for a simplified concrete foundation slab.

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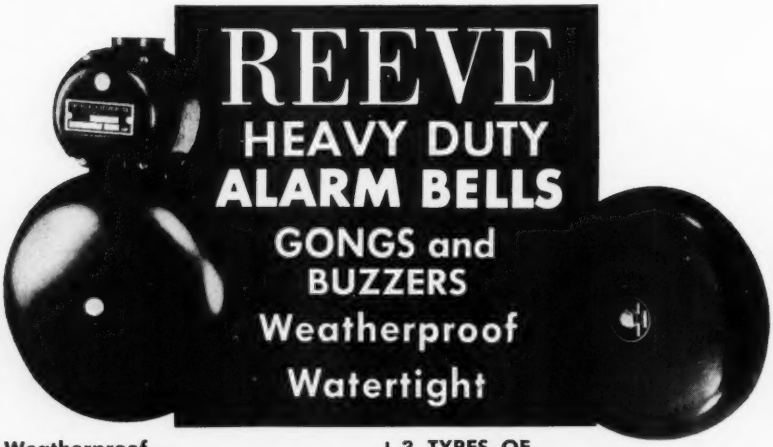

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Weatherproof —
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Voltages are the same as Neck Type

Special Windings on request.

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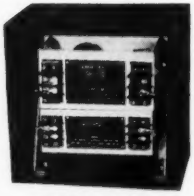
The unit is designed for use on any storage batteries not subject to heavy drains. It will trickle charge the battery indefinitely because of its automatically decreasing rate of charge.

For use with six cells (12 volts). Automatically controlled by saturable reactor. Continuous output one ampere. 22.5 watts, 118 volts, 60 cycles. 3% Regulation. 9" x 9" x 6" — 14 B & S gauge steel wall cabinet. 15¼ lbs. U.L. Approved. No moving parts.



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• automatic alarm devices • sprinkler alarm and supervisory devices • burglar alarm devices and accessories. DYNALARM (sound detection for both reverberant and non-reverberant vaults).

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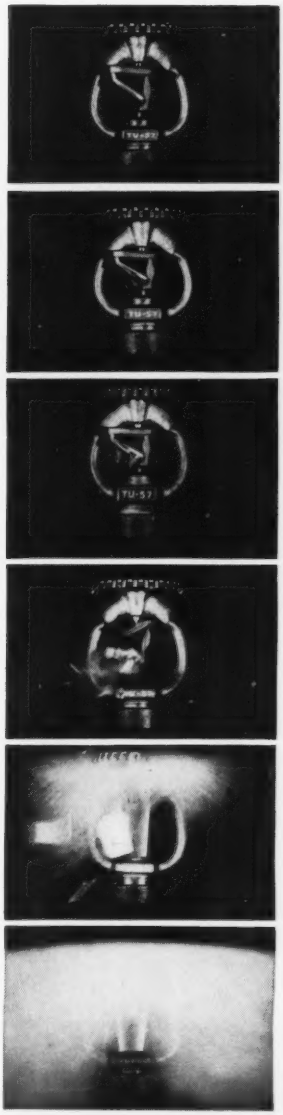

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in one-tenth of a second!

The eye of the high-speed movie camera shows you what the human eye is not quick enough to see — the actual operation of the Rockwood WaterFOG Sprinkler Head. And it all happens in one-tenth of a second after the solder starts to melt. Then water sprays out to put out the fire fast.

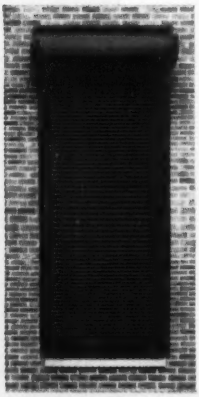
Rockwood can engineer a complete fire protection system for you — a wet, dry pipe or Dualguard system. Whatever your special fire hazard problem, small or large, Rockwood can solve it!

Write for Rockwood's booklet, "Do You Have a Hidden Enemy in Your Plant?" It lists dangerous hazards and how to protect your plant from the fire losses they can cause. Tested and listed by Underwriters' Laboratories, Inc. Rockwood Sprinkler Company, 2967 Harlow Street, Worcester 5, Mass.

ROCKWOOD SPRINKLER COMPANY

Engineers Water...to Cut Fire Losses

Automatic Rolling Steel FIRE DOORS *and* WINDOW SHUTTERS PREVENT SPREAD *of* FIRE



You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or write for Catalog G-58.

THE R. C. MAHON COMPANY • Detroit 34, Michigan
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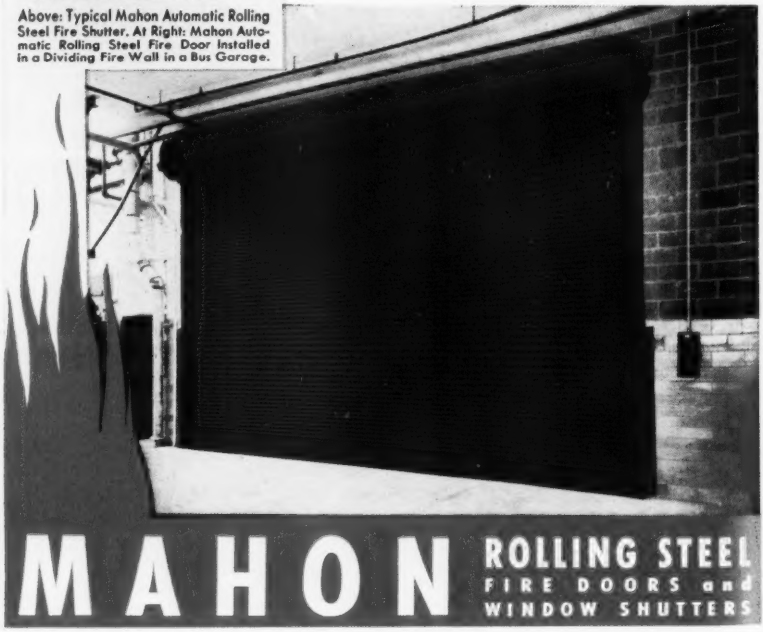
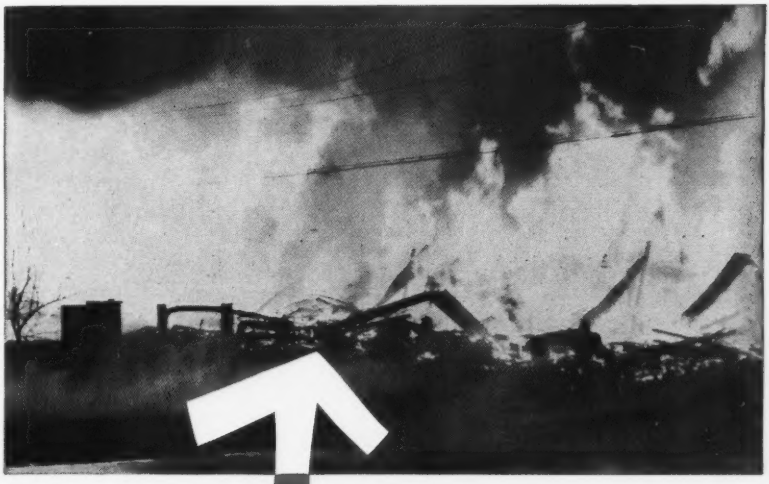
Manufacturers of Standard and Underwriters' Labeled Automatic Rolling Steel Fire Doors and Window Shutters; Underwriters' Rated Metalclad Fire Walls; Insulated Metal Curtain Walls; Electrified M-Floors; Steel Roof Deck; Acoustical Long Span M-Decks; and Acoustical and Troffer Forms.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.



MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS



this was so unnecessary

A Blaw-Knox Automatic Sprinkler System could have prevented it

Most uncontrolled fires are unnecessary. The damage in property destroyed, plants lost, inventories wiped out, records ruined, and businesses shut down can never be recovered. A Blaw-Knox *Automatic* Sprinkler System can stop fires at their origin, minimize damage to a small area, and pay for itself in a few years by savings in reduced insurance premiums.

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BLAW-KNOX COMPANY

Automatic Sprinkler Department
Power Piping and Sprinkler Division
829 Beaver Avenue, Pittsburgh 33, Pa.

SAFER

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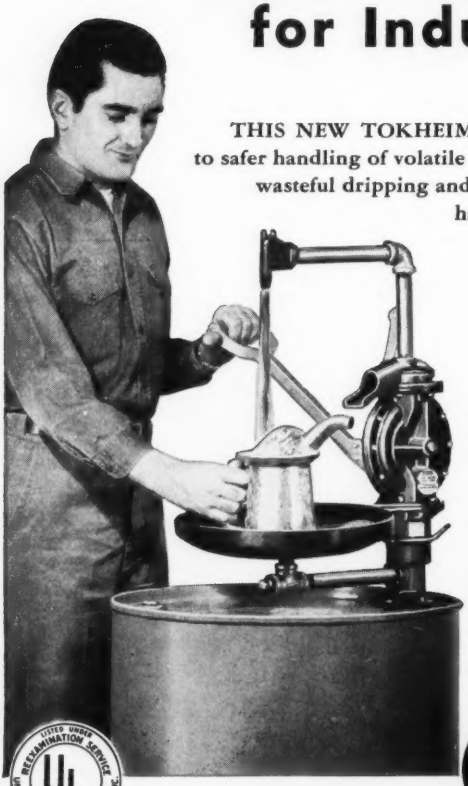

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Write factory for literature.

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QUALITY TOKHEIM HIGH VACUUM HAND PUMPS

General Products Division

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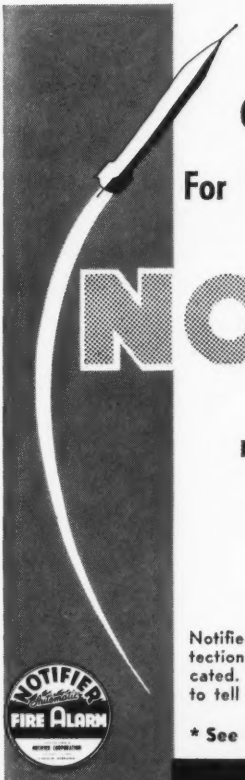

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Notifier's nationwide organization offers exceptional opportunity for sales engineers trained in fire protection, municipal fire alarms, or electronics, and experienced in dealing with executives at top level. Dealerships open to substantial companies willing to set up independent sales and service department with capital and manpower adequate for handling large installations running into high five figures.

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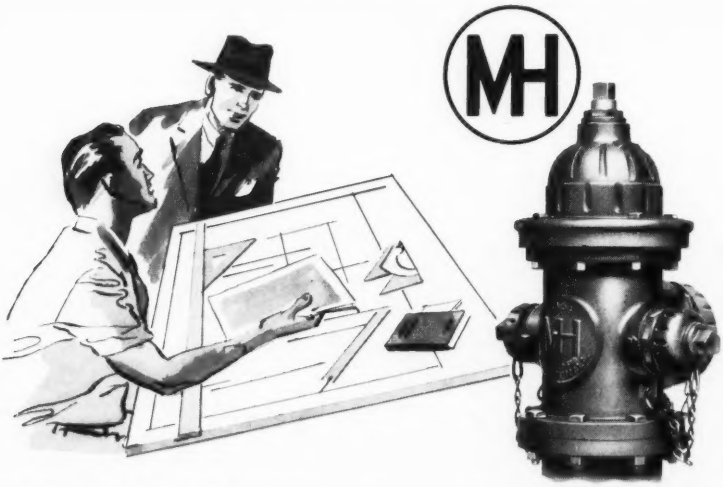

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Modern engineering and practical water works experience account to a great extent for the advantages and superiority of M & H valves and hydrants. In this respect, many M & H customers are unofficial members of our engineering staff. From their every-day operating experience, these men "on the firing line" have contributed greatly to the modern design of M&H products.

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2½-lb. Pressurized Dry Chemical

5-lb. Pressurized Dry Chemical

Kidde dry chemicals kill more fire faster

Granted top rating by Underwriters' Laboratories, these two new Kidde extinguishers pack an extra punch, put out as much fire as eight and sixteen one quart CTC portables respectively. Perfectly balanced, light in weight, easy to operate, no pin to remove, no valves to turn, no inverting or bumping needed. Just aim and press lever! No pressure cartridge needed. Write for more information on these new Kidde extinguishers – easiest-to-operate dry chemical portables on the market today!

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VICTAULIC COUPLINGS

Styles 77, 77-D for standard applications. Simple, fast to install — sturdy and reliable. Sizes ¾" to 30". Style 75 Light-Weight Couplings for light-duty applications. Sizes 2" to 8". Additional styles for cast iron, plastic and other pipes. Sizes through 60".

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Style 99 for plain or beveled end pipe. Best engineered, most useful plain end joint on the market. Simple, husky — easy and fast to install. Takes strong bull-dog grip on pipe. Sizes 2" to 12".

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Handy, on-the-job grooving tools that do the job in half the time. Light weight, easy to handle — operate manually or from any power drive. Automatic groove position and depth. Sizes ¾" to 8".

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Every minute of the day and night, Reliable automatic sprinklers are acting as miniature fire control teams . . . standing ready to automatically detect, sound the alarm, and extinguish fires in their incipient stages.

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For perfect FIRE CONTROL . . . Let your local Reliable Licensee show you the RELIABLE FIRE CONTROL TEAM . . . We'll see that he contacts you promptly.

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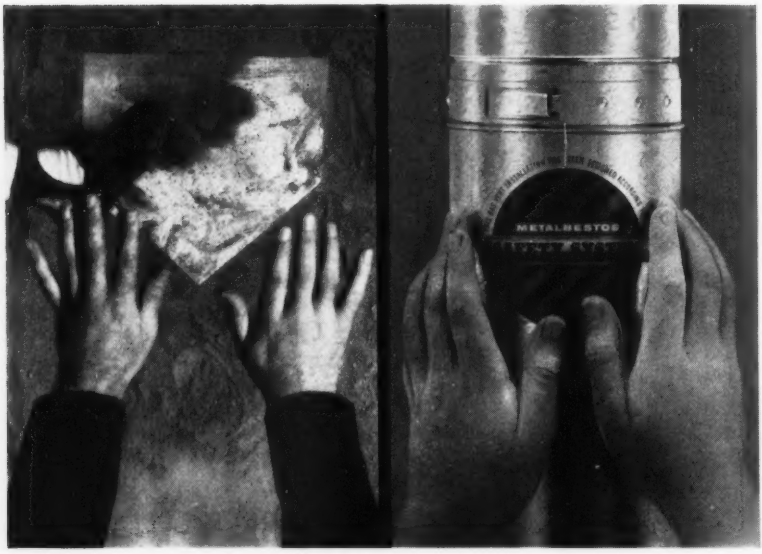

SAFE AT HOME

Umpires use a special sign to call a player "Safe at Home"... and so do gas vent installers when they want to tell building inspectors the same thing. It's the red-and-black Metalbestos "Safety Seal"... placed on the gas vent above the appliance's draft hood as proof of safe, trouble-free gas venting for the life of the home.

The Metalbestos "Safety Seal" means that an all-Metalbestos gas vent has been designed and installed according to the Metalbestos "Safety System" Gas Vent Tables... recognized throughout the gas industry as the modern, scientific standard for safe gas venting. Watch for the distinctive Metalbestos "Safety Seal"... sure sign that gas consumers within your jurisdiction will receive the full benefits of safe, efficient gas venting.

For your complimentary copy of the new "Safety System" Installation Guide, contact your nearest Metalbestos representative or write Dept. T-10.

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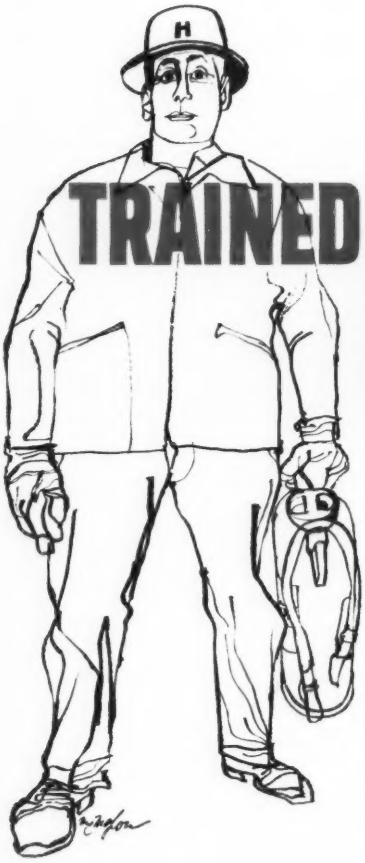


IN FIRE EMERGENCIES

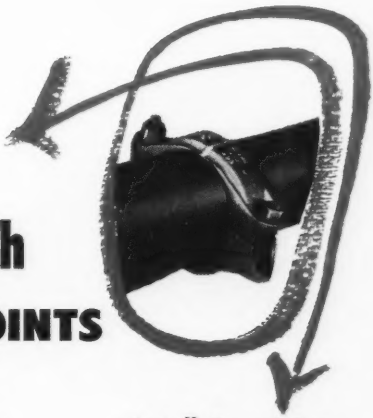
TRAINED PEOPLE MAKE THE DIFFERENCE

Training your people is one of Ansul's most important jobs. In your own plant, at our Fire School in Marinette, Ansul experts instruct your men in the latest fire fighting techniques. This training is only part of Ansul's unique service program. In addition, you receive thorough fire protection surveys of your plant, visual aids to make your employees fire-prevention conscious. Trained men, fire prevention planning—plus Ansul fire extinguishing equipment give you the complete protection you need. Write us. Let us tell you about the Ansul service plan.

ANSUL CHEMICAL COMPANY / MARINETTE, WISCONSIN

FIRE EXTINGUISHING EQUIPMENT / INDUSTRIAL CHEMICALS / REFRIGERATION PRODUCTS / NATIONAL DISTRIBUTORS OF "FREON" REFRIGERANTS

Couple Pipe the Easy, Low Cost Way with New G-B GRUVAJOINTS

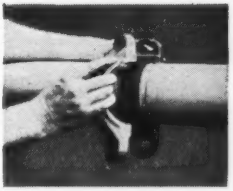


Now you can save up to 25% when connecting pipe for bulk runs and risers.

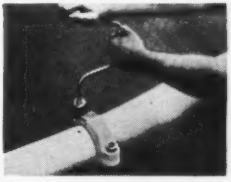
Yes, contractors are saving money every day when they use new lightweight Gruvajoints. There's no flanging, no threading, no welding, and there's no need for heavy chain tongs or pipe wrenches. Gruvajoints are truly the modern way to couple pipe. Write today for free illustrated brochure on G-B Pipe Coupling Products. Gruvajoints are now available in 2", 2½", 3", 4", 5", 6" and 8" sizes.

Install Gruvajoints in three easy steps

Grease gasket and center over pipe ends.



Lay housing halves into grooves and insert bolts.



Tighten the two nuts equally.

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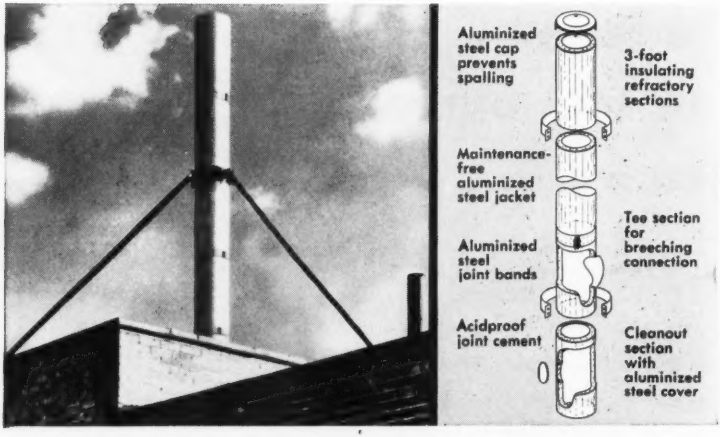
Report Serial No. 13097

GUSTIN-BACON
manufacturing company
210 W. 10th St. Kansas City, Missouri


Aluminized steel cap prevents spalling
3-foot insulating refractory sections
Maintenance-free aluminized steel jacket
Tee section for breeching connection
Aluminized steel joint bands
Acidproof joint cement
Cleanout section with aluminized steel cover

New prefabricated refractory smokestack is safe, permanent

Permanence — The Van-Packer Industrial Stack is made of 3-foot long, non-corroding refractory sections cemented together with acidproof cement and secured with aluminized steel joint bands. Sections have maintenance-free aluminized steel jacket.

Safe — Van-Packer Standard Stack, for boilers and furnaces, withstands flue gas temperatures to 800°F. Van-Packer Hi-Temp Stack, for incinerators, withstands 2000°F., continuous exposure. Safe for all fuels.

High draft — Insulating qualities of refractory wall prevent heat loss, give draft equal to a brick stack, greater than a steel stack. Eight diameters from 10" I.D. to 36" I.D. Wall thickness varies from 2 to 4 inches depending on diameter.

Tested and proved — Write for 32-page report on test data from independent laboratories, and Bulletin IS-32 with complete product information and specifications.

Van-Packer PREFABRICATED REFRACTORY Stack

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1232 McKinley Ave., Chicago Heights, Ill. • Phone: Skyline 4-4772

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Steel Rolling

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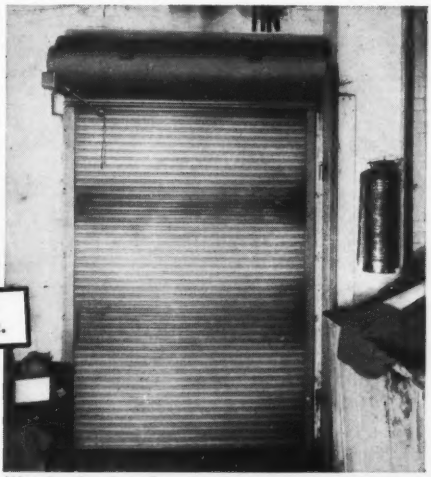
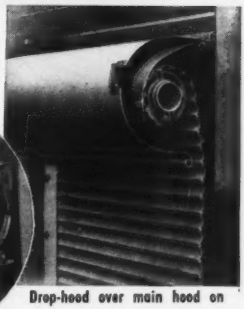
LABELED by Underwriters Laboratories, Inc.

Automatic_positive-action Closure

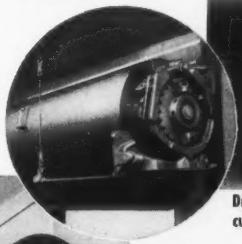
You get *positive, automatic* fire protection wherever openings are equipped with AKBAR Rolling Fire Doors (made *only* by Kinnear). The instant fire causes *automatic* release, they are *pushed* downward by a strong spring. Their closing speed is *controlled*, for safety. And they're operable *after* automatic release, for emergency exits.



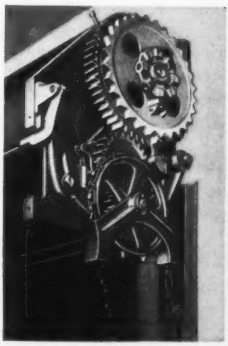
Akbar Fire Door just after confining a devastating fire to room on other side of fire wall. Note fire extinguisher still on wall.

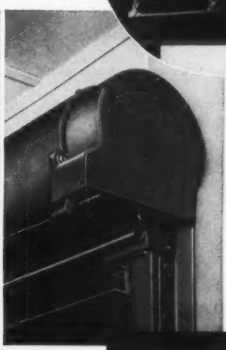


Drop-hood over main hood on curtain coil.



Right and below right: Manual Akbar operating mechanism. Below left: Mechanism of chain hoist "Akbar" Fire Door.





When closed, AKBAR Rolling Fire Doors block drafts, repel flames, keep fire from spreading. Kinnear Rolling Fire Doors can also be equipped for daily service, with motor or manual operation. (Use non-labeled Kinnear Rolling Doors where fire protection is not required.) Write for full details!

The KINNEAR Manufacturing Co.

Factories:

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KINNEAR

ROLLING DOORS

Saving Ways in Doorways

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SMALL ORIFICE SPRINKLER
(With Identifying Pintle)

1 **SUPERIOR PROTECTION** . . . due to more efficient water distribution. Proven by tests under actual fire conditions for all classes of hazards.

2 **MORE EFFECTIVE USE OF LESS WATER** . . . because wider distribution and break-up of the water discharged provides greater cooling and extinguishment.

3 **CEILING PROTECTION BY COOLING — NOT WETTING** . . . All the water goes onto the fire. The break-up of water results in complete cooling and control of flammable vapors.

4 **MORE FIRE CONTROL WITH FEWER SPRINKLERS** . . . because ceiling temperatures are kept lower, fewer sprinklers open. Immediate water saturation of the fire area prevents the spread of fire. Hot gases become impotent in the cooled atmosphere.

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Duct Cleaning and Fireproofing

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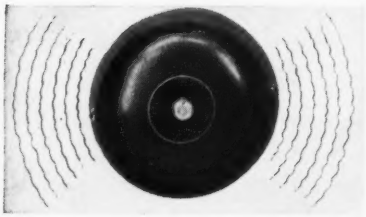
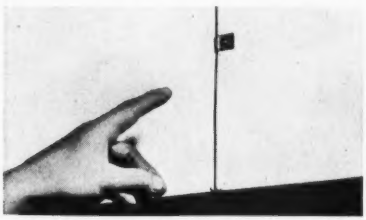
FIRE ALARM!

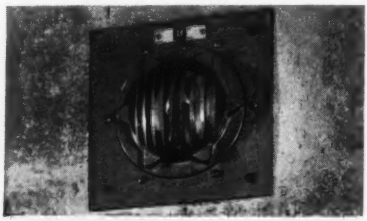


1. Save priceless lives, protect valuable buildings with the Kidde Atmo Fire Detecting and Alarm System!

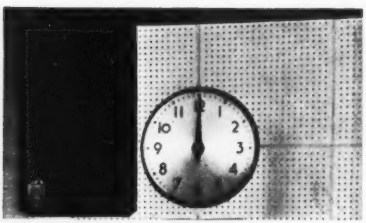
2. This automatic detecting and warning system sounds an alarm instantly at the *first* hot breath of fire!



3. Using rate-of-temperature-rise tubing as a sensing element, the system works without outside power!



4. Kidde's Atmo system can sound alarm at fire area, outside the building or at local fire department station!



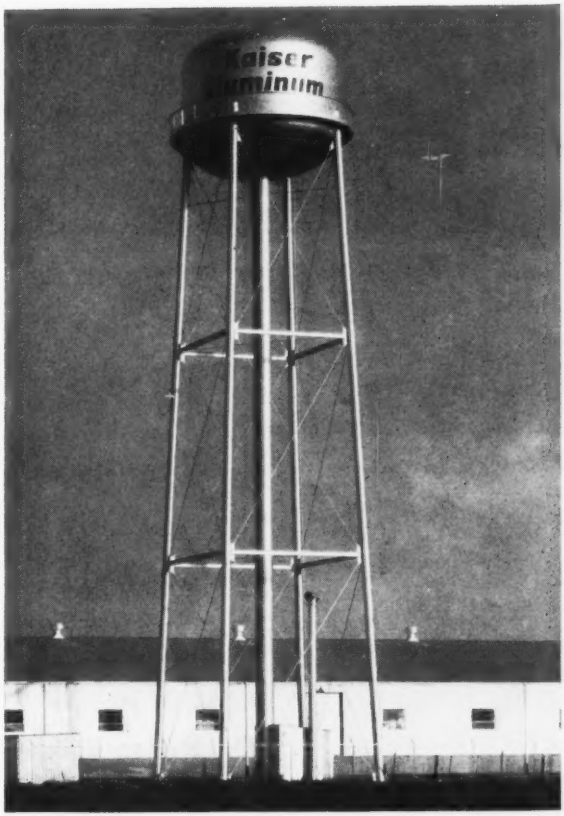
5. Kidde's Atmo system also gives fire location at a panel near any manned telephone switchboard!

Kidde Atmo
FIRE DETECTION
KIDDE ULTRASONIC & DETECTION ALARMS, INC.
9 Brighton Road, Allwood, N. J.

A Subsidiary of
Walter Kidde & Company, Inc.

FOR fast, dependable fire detection and warning, install a Kidde Atmo Fire Alarm System. Ideal where life protection and early fire warning is essential, the Kidde Atmo system can also close doors, shut off fans, motors, blowers, is automatically re-setting after use or test. Get more information! Write today and ask for Kidde's Atmo Alarm Systems booklet!

Chicago Bridge & Iron Company



Horton Tank Provides Dual Service and Aids In Insurance Savings

The new food container plant of Kaiser Aluminum and Chemical Corporation, near Wanatah, Indiana, has 50,000 gallons of water for fire protection and 25,000 gallons for general plant use stored in a 75,000 gallon ellipsoidal bottom elevated tank with a height to the bottom capacity line of 100 feet. Studies of insurance savings that would result from the sprinkler protection prompted the decision to erect this tank which is sufficiently large for future plant expansion.

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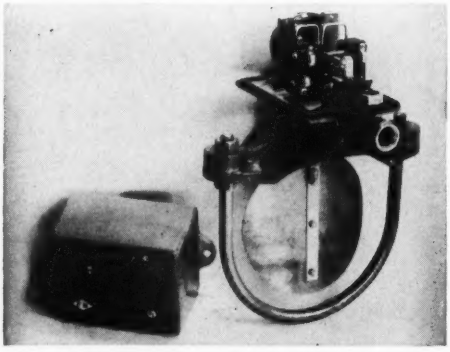

Model PRS-1

Sprinkler Waterflow Alarm

This device is approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc.

- This device is also made as Model PRT-1, a coded waterflow transmitter.

5-inch size shown above. To install simply drill 2-inch hole in pipe.

- Also made in explosion proof models.
- Made in all sizes from 2½" to 8".
- Has instantly recycling pneumatic retarding device, preventing false alarms.
- Has enclosed electrical contacts for any voltage not exceeding 15 amp. 125 volts, A.C. and ½ amp. 125 volts, D.C. Operates on all water pressures or surges.

Size is 1⅝" x ⅝"

Tempo-Set Model A Fire Detector

Underwriters' Laboratories, Inc. Approved.

- Self restoring and can be heat tested.
- Electrical contacts are silver or gold and are enclosed.
- Very reasonable price.

- Tempo-set Model A is approved in either open or closed circuit and the temperature ratings are 135 and 200 degrees.
- Approved maximum distance between thermostats on smooth ceilings: 20 feet.
- Electric ratings are 125 volts 1 ampere, A.C. or 24 volts 0.5 ampere D.C. or less.

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New Design Sprays Water More Evenly Over Wider Area!

It's hard to improve on the best, but we've done it! By re-designing our already superior "Automatic" Spray Sprinkler, we have come up with a model that has an even *better* distribution pattern. We also made the casting more rugged. The resultant increase in efficiency means better performance in case of fire. While we were at it, we improved our sprinkler's appearance.

Available for upright or pendant installation.

Ask your nearest "Automatic" Sprinkler fire safety engineer or write to us for complete information.

"AUTOMATIC" SPRINKLER CORPORATION OF AMERICA
YOUNGSTOWN, OHIO
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"Automatic" Sprinkler

FIRST IN FIRE PROTECTION

A Tragedy In Chicago...

was told in grim detail recently in newspaper headlines across America. 90 children and three adults lost their lives in a Chicago school fire. The news stunned the nation.

We at Gamewell are deeply concerned. Our sole business for over 100 years has been automatic fire detection and alarm systems. We know that science has provided equipment to prevent such tragedy.

Tragedy is a teacher. But often, after the headlines have faded, tragedy's greatest ally — *a man's own short memory* — lulls communities into complacency. Chicago's disaster gives mute testimony of the great danger of fire — and that hazards of fire are everyone's business.

If you are concerned with the safety of your children in your community's schools, have your Fire Chief, or School Board Official contact a Gamewell engineer. He is a highly trained expert in fire detection who can give you information, examples of fire alarm installations, and he will survey your buildings.

He is backed by the largest plant in the world engaged exclusively in the manufacture of fire and other emergency signalling systems and equipment. Have your official phone the nearest Gamewell office — we will gladly accept the charges.

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Solving tough fire problems like this with installations engineered to the hazard, tailored to the need, built of highest quality materials is something Grinnell has been doing successfully for more than 85 years. Check the list below for the Grinnell System suited to your requirements. Or, tell us about the fire hazard you face, and let us suggest the proper installation for you. Grinnell Company, Inc., 277 West Exchange Street, Providence, Rhode Island.

Grinnell Fire Protection Systems include:

- Automatic spray sprinklers — wet pipe, dry pipe, Simplex*, and deluge systems
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- Cooling, insulation and controlled burning with water sprays—ProtectoSpray* systems
- Mechanical foam blanket — Protecto-Foam* systems
- Carbon dioxide systems
- Dry chemical systems

*Trade Mark Registered

GRINNELL Whenever Fire Protection is Involved